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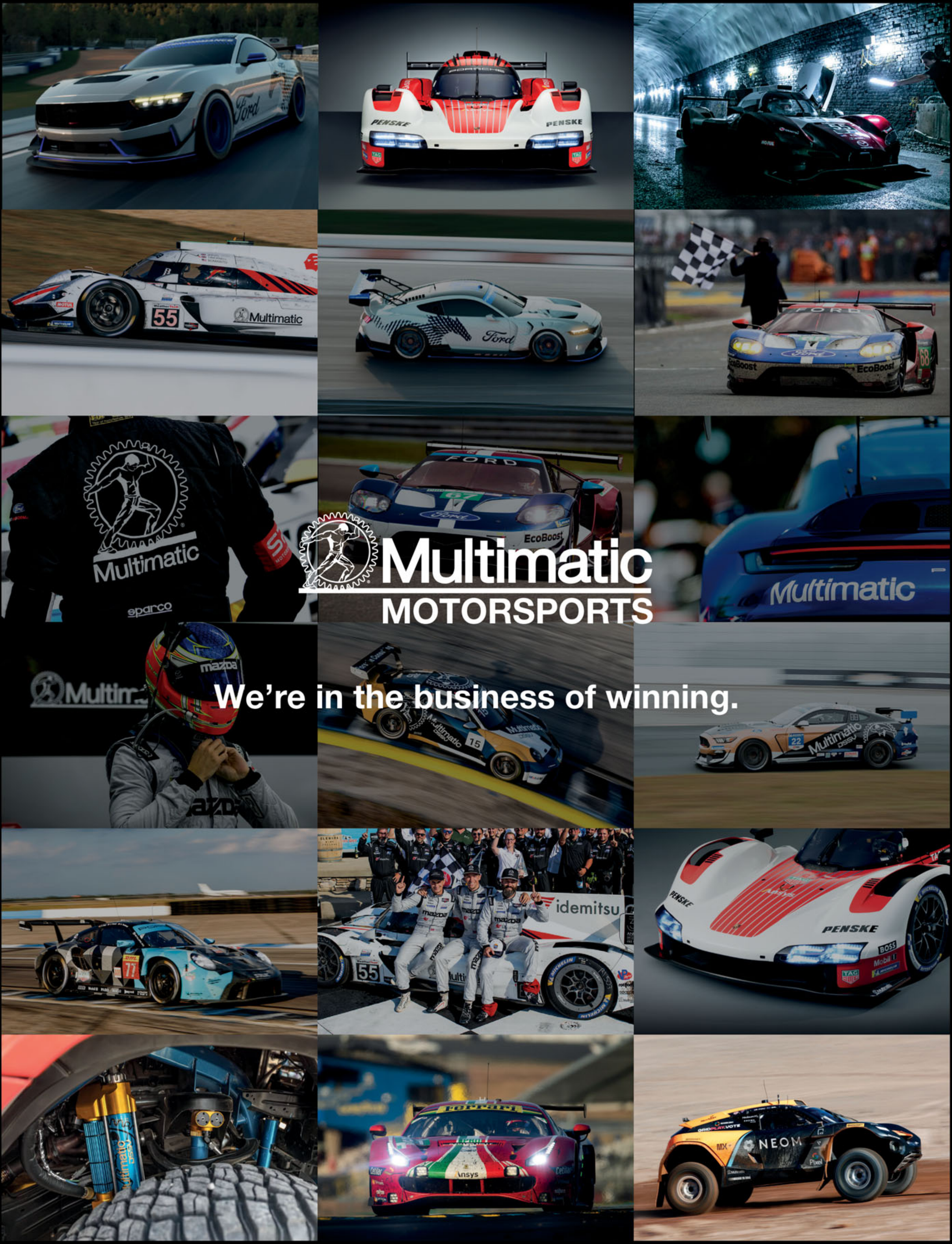
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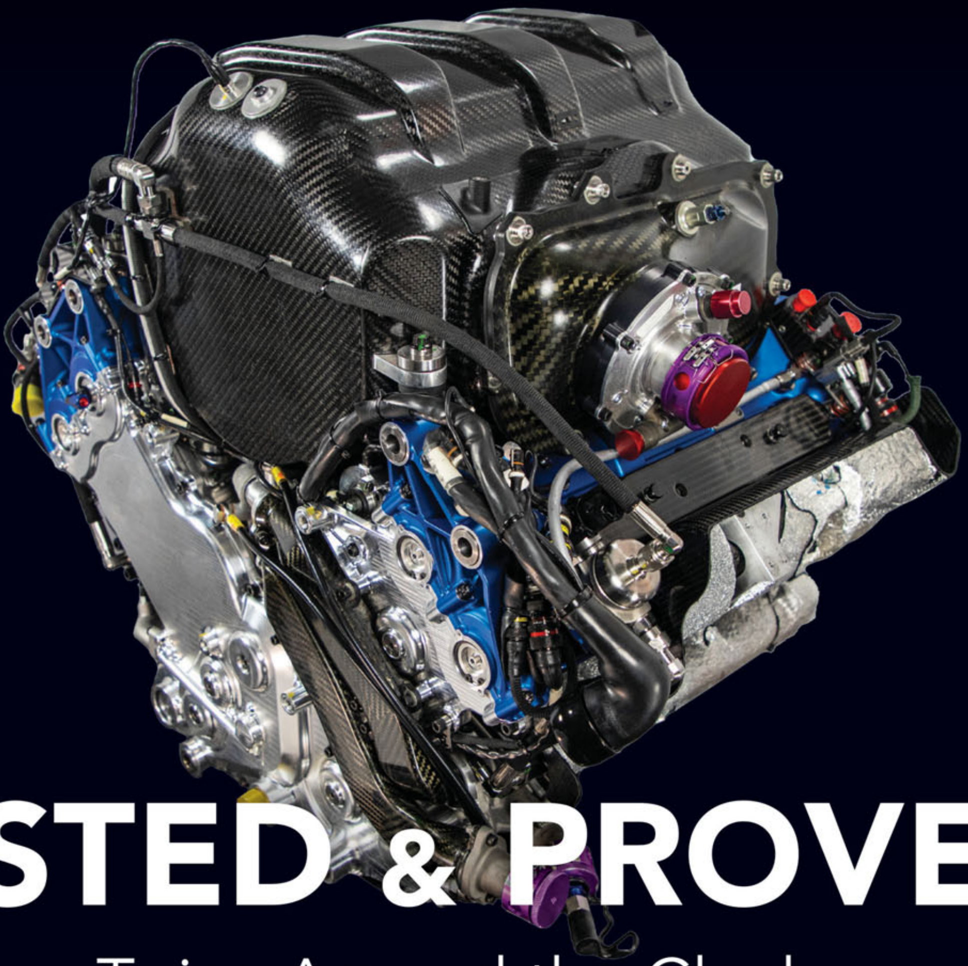

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SURVIVING A BAPTISM OF FIRE

WHATEVER your profession, those moments before 'going live' with something new are exhilarating / excruciating / nerve-jangling: delete as applicable!

So it was in the run up to this year's Rolex 24 at Daytona International Speedway. The endurance classic was the first major test for the electrified GTP prototypes. There was much to enjoy, even more to go wrong.

It was a true baptism of fire. Given the problems that surfaced in even the most recent testing, would any of the top class even finish? Was IMSA staring down the barrel of an embarrassing LMP2 giant-killing overall victory?

It could have been messy. Yet eight of the nine hybrid GTPs were still running at the end of 24 hours, headed by the top two Acura ARX-06s and two Cadillac V-LMDhs in P3 and P4, all on the lead lap.

Sure, one of the BMW M Hybrid V8s finished 100+ laps down after issues with the spec hybrid powertrain and one Porsche Penske Motorsports Porsche 963 did not finish at all, after suffering a broken gearbox. But an 89 per cent finishing rate would be an outstanding feat for any class in any 24-hour race, let alone for complex prototypes making their bow after a frantically short development period.

Yes, there were reliability problems, but there always have been in endurance racing. Over the years, we have become used to conventional components evolving to become near bullet-proof, but with the electrification of motorsport we are trying to find new solutions without the luxury of a money-no-object approach. More than ever, we have to be clever within the challenging constraints of cost control.

As you can read elsewhere in this magazine, in our interview with Gen3 lead Alessandra Ciliberti, Formula E – the biggest disrupter of all – is facing a similar juggling act. And doing an extraordinary job in the process.

I was struck by some comments made over the Daytona weekend by NASCAR President Steve Phelps. He pointed out that, back in 2018, NASCAR, Formula 1 and IndyCar all appeared to be in trouble. Looking back, the racing could often be predictable, and the future technical direction was uncertain.

Now, NASCAR's Next Gen car has brought it into the modern era in impressive fashion. Like F1, it has significantly improved the racing.

In fact, everywhere you look, there is cause for optimism. The World Rally Championship's first innovation forum, in Monte Carlo last month, underlined the manner in which it too has embraced a sustainable pathway. It has introduced new cars, hybrid technology and, like the World Endurance Championship, has sustainable fuel. IndyCar will follow suit next month with its fuel, with hybrids under development.

It is all work in progress, of course. The next rulesets will be upon us before we know it, and there are more difficult decisions ahead. Nevertheless, it is an impressive comeback.

Mark Skewis
EDITOR

BUTTON JOINS ALL-STAR G56 NASCAR SQUAD

1948
NASCAR 2023
NASCAR

Photos: Getty Images/NASCAR

Beneath the headlines, data from the Garage 56 Le Mans experiment could help transform NASCAR. By **Mark Skewis**

NASCAR'S Garage 56 entry for the Le Mans 24 Hours, raced by an all-star driver team, represents an "awesome opportunity" to promote the stock car series on a global stage.

That's the opinion of Garage 56 project leader and IMSA president John Doonan.

The project already boasted the most successful team and manufacturer in stock car racing history, in Hendrick Motorsports and Chevrolet, allied to NASCAR's tyre partner since 1954, Goodyear. Now NASCAR has revealed a sensational and multi-talented driver line up too: former F1 world champion Jenson Button will join seven-time NASCAR Cup Series champion Jimmie Johnson and 2010 Le Mans winner Mike Rockenfeller.

"I would suggest if there is ever such a thing as an All-Star team in motorsports, this project is the absolute poster of that," commented Doonan.

While the original plan was formulated with the intention of showcasing the Next Gen car to a wider audience, Doonan divulged that things had come full circle. Some of the aerodynamic discoveries made during the test programme are about to be fed back in to the Next Gen machine as NASCAR seeks to improve the car even further for its second season.

"We've learned a lot already about this car and what might be able to be applied to the Next Gen Cup car," said Doonan of the Garage 56 variant. "Just this week, based on the work Rocky has done in the sim, Jimmie has done in the sim, Jenson in the sim, Dr Eric Jacuzzi, our aerodynamicist for NASCAR, there were components that we've tested on the Garage 56 car that were tested at Phoenix that might be applied for short track racing or road course racing."

The experiments with headlights, a must for endurance racing, also raised interest during a two-day test held at Daytona after the Rolex 24.

"Working headlights, working taillights. No more stickers," said Doonan. "We're really excited about that, to help maybe bring some things from this project that could be applied, and again, it's all about putting NASCAR on a global stage."

Chance encounter

The surprise involvement of Button, aged 43 and a 15-time Grand Prix winner, had its roots in a chance conversation with Jimmie Johnson.

"I was just asking Jimmie what he was up to in 2023, because this guy can't sit still," he revealed. "He was running through a few things he's hoping to do, and he said, 'I'm hoping to bring NASCAR to Le Mans.' I was like, 'Sorry, what?' It started there…"

Three-time IMSA champion Jordan Taylor also will join the Garage 56 effort as a reserve driver and a driver coach. Taylor has made four appearances on the podium at Le Mans, including a GT class win in the 2015 edition.

The first test day was used for driver acclimatisation, the second for endurance running. The Chevrolet Camaro ZL10 was sent out for successive long runs of roughly 25-30 laps each on day two, stopping in the garage for quick adjustments, data downloads and practising driver changes and pit stops. Garage 56 crew chief Greg Ives said the test car accumulated approximately 1,500 miles during the two days, running for roughly nine and a half hours of the 12-hour testing block on the second.

The car's unofficial lap times initially compared to those at the top of the GTD class from the IMSA series opener at Daytona. By late on the second day, the Next Gen-based car had gained enough speed that with Rockenfeller behind the wheel it caught and passed the 2024

Chevrolet Corvette Z06 GT3.R that shared the track in the two-day test – drawing a special mention over the team communications.

The crew cycled through several throttle-map settings, working toward target numbers on performance, fuel consumption and mileage. Tyre wear was also a focus.

Hendrick Motorsports worked closely with Dallara, leaning on its sportscar experience to develop the lighting system, including supplementary apex lights. The speedway lowered its lights to better replicate Le Mans-style conditions as the car ran deep into the darkness.

> *“‘I was blown away,’ admits Button”*

“In general, the car’s probably from a fundamental configuration standpoint pretty close to what we’re going to have when we go to Le Mans in June,” said Garage 56 project lead Chad Knaus, Hendrick Motorsports’ VP of Competition. “We’ve had some small electrical gremlins that are creeping up occasionally like we’ve heard a lot here recently in motorsports, so we’re trying to get that stuff sorted out.” RT

How a visit to NASCAR’s Dream Team clinched the deal

IT was a visit to NASCAR’s most successful team that ultimately persuaded 2009 F1 World Champion Jenson Button to accept the offer to race a NASCAR at Le Mans.

Asked if he had to overcome any reservations about the project, Button responded: “Reservations, no. I wanted to understand the project a lot more and I wanted to spend a bit of time with the team, speak to the drivers. I visited Hendrick Motorsports, and I have to say I was blown away at the facility.

“I’ve raced for some of the best Formula 1 teams in the world, and it still surprised me how good the facility was, the intrinsic detail that goes into everything they do within the team.

“I knew they would be developing and producing a fantastic car for us to race at Le Mans… I’m very excited to work with this All-Stars team, and I think we can achieve something very special.”

Button has raced at the endurance classic before, in 2018, and admitted that it was an eye-opener for him.

“Before I went there, I was like, ‘What’s the big deal with Le Mans?’” he said. “I thought Formula 1 is the pinnacle. But Le Mans is such a special race. It’s such a big team event.

“We all have to work together to perform and to get a result out of it. Even though I didn’t finish in 2018, it just got me excited to go back there for more.” RT

ABOVE LEFT The test was the first time a NASCAR had run with working headlights

NASCAR 2023
GARAGE 56
MANS

RIGHT Button was impressed when he first saw and heard the NASCAR

Sustainability agenda lures Ford back into F1

AFTER more than two decades, Ford is returning to Formula 1. The iconic American automaker and Red Bull Powertrains are entering into a long-term strategic technical partnership for the development of a next-gen hybrid power unit to be used from the 2026 Formula 1 season onward.

Red Bull Ford will provide the power units for both the Oracle Red Bull Racing and Scuderia AlphaTauri teams from 2026 to at least 2030.

Ford cited F1's commitment to sustainability, with increased use of electric power as well as sustainable fuels, as key reasons for its return to the sport that it dominated back in the late '60s and '70s.

"Ford's return to Formula 1 with Red Bull Racing is all about where we are going as a company – increasingly electric, software-defined, modern vehicles and experiences," said Jim Farley, President and CEO, Ford Motor Company. "F1 will be an incredibly cost-effective platform to innovate, share ideas and technologies, and engage with tens of millions of new customers."

Ford will provide technical expertise in all areas where it can add value to the front-running World Championship team. Areas to be explored together are in the combustion engine development and key developments like battery cell and electric motor technology, power unit control software and analytics.

"As an independent engine manufacturer, to have the ability to benefit from an OEM's experience like Ford puts us in good stead against the competition," said Christian Horner, Oracle Red Bull Racing Team Principal and CEO. "They are a manufacturer rich in motoring history that spans generations. From Jim Clark to Ayrton Senna and Michael Schumacher, the lineage speaks for itself. For us as Red Bull Powertrains to open the next chapter of that dynasty, as Red Bull Ford, is tremendously exciting. 2026 is still a while away but for us the work already starts as we look to a new future."

Starting from 2023, Ford and Red Bull Powertrains will work to develop the power unit that will be part of the new technical regulations, including a 350 kW electric motor and a new combustion engine able to accept fully sustainable fuels, ready for the 2026 season.

Stefano Domenicali, President, and CEO of Formula 1, commented: "Ford is a global brand with an incredible heritage in racing and the automotive world and they see the huge value that our platform provides with over half a billion fans around the world. Our commitment to be Net Zero Carbon by 2030 and to introduce sustainable fuels in the F1 cars from 2026 is also an important reason for their decision to enter F1."

Ford's negotiations with Red Bull are said to have succeeded where Porsche had failed because the US company sought no equity stake. Red Bull's media-awareness was also a big lure in the decision process for Ford.

Ford is investing $50 billion to lead the EV revolution around the world. It is the number two US EV automaker in the US, driven by the success of the F-150 Lightning and Mustang Mach-E, as well as the market leader in many markets around the world with the E-Transit. Ford is working to meet increased consumer demand and deliver an annual run rate of 600,000 electric vehicles globally by the end of this year and two million globally by the end of 2026 as part of its Ford+ plan.

Despite leaving the sport in 2004, Ford remains the third most successful engine manufacturer in F1 history with 10 Constructors' championships and 13 Drivers' championships. Its last title victory came as its engines powered Benetton's Michael Schumacher to the 1994 drivers' crown.

In 2000, Ford bought the Stewart Grand Prix team and renamed it Jaguar Racing, but the team was sold to Red Bull after five seasons. RT

LEFT Ford is to partner with Red Bull Powertrains to produce a next-gen F1 engine for 2026

BELOW The Blue Oval's last big F1 project was with Jaguar Racing

Ford

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GM TO F1? WHAT'S NOT TO LIKE?

Mark Skewis reports on Andretti's controversial bid to break F1's closed shop with Cadillac coup

WITH a flourish worthy of an ace conjurer, Michael Andretti provided the perfect riposte to those teams struggling to resist the American group's overtures towards Formula 1: a deal with General Motors to bring the Cadillac brand into grand prix racing.

The coup of landing one of the world's largest car makers provides the perfect calling card for Andretti Global's bid to join the sport's top tier. But it still might not be enough.

Not so long ago the tail-enders of the F1 field were invariably going bankrupt, struggling to make it to every race with enough spare parts. Now, however, the new-look F1, complete with the catnip factor of extra-added sustainability, is an attractive proposition. The existing franchises know that and not even the $200m sweetener – $20m per team – is considered sufficient compensation for diluting the teams' share of the prize fund.

Thwarted in an attempt to buy Sauber in 2021, Andretti has since encountered opposition from established F1 squads. The announcement that Andretti Global will partner with GM and bring a major manufacturer to the sport if it grants an entry, was therefore a masterstroke.

"One of the big things was, what does Andretti bring to the party?" Andretti acknowledged. "Well, we're bringing one of the biggest manufacturers in the world

Pirelli

ABOVE The operation would be run from Andretti's new $200 million facility at Fishers, Indiana, with a satellite operation in Europe

LEFT F1 expanded its presence in North America with its first race in Miami last year. But not even the dream ticket of an all-American entry has wooed the existing teams

now with us with General Motors and Cadillac. So we feel that was the one box we didn't have checked that we do have checked now.

"That, I think, will be bringing a tremendous amount of support to Formula 1. And it's hard for anyone to argue that now."

As the realization dawned that the majority of the teams still weren't budging, Andretti accused them of being "greedy". It was, he said, "all about money". And he's not wrong.

"Andretti is a great brand, a great team," accepted Red Bull team principal Christian Horner. "Mario, what he did in Formula 1 – as an American as well – is fantastic. Obviously GM with Cadillac as well would be two phenomenal brands to have in the sport, and I don't think there can be any dispute about that.

"As with all these things though, it ultimately boils down to, 'Well, who's going to pay for it?' And you can assume that the teams, if they're perceived to be the ones who are paying for it – or diluting their payments to accommodate it – of course it's not going to sit that well."

What's in it for GM?

General Motors believes that the combination of its engineering expertise and the growth of the Cadillac brand makes now the perfect time to join forces with Andretti Global for a Formula 1 entry. GM has never entered F1 but its president, Mark Reuss, said an involvement would complement Cadillac's existing racing projects.

"I couldn't be more excited to write this new chapter of racing history together," Reuss said. "Like Andretti Global, General Motors and our brands have a long history in motorsports and a deep passion to race. Our racing pedigree has been forged on some of the greatest ▶

tracks and races around the world.

"Like Formula 1, Cadillac's global appeal is growing. In fact, Cadillac is one of the world's fastest growing luxury brands right now. You could see that in some of our close of the year and the month here on Cadillac sales.

"By racing, in IMSA, WEC and F1, Cadillac will have the opportunity to showcase its innovation and technology by going up against the best international luxury brands.

"At GM, we've always taken a lot of pride in transferring the cutting-edge technology developed by our race teams to our production vehicles, and taking it from the track to the street. For Cadillac that means V Series. Cadillac's passion for performance is embodied in the V Series portfolio, which puts racetrack technology and performance into the hands of our customers."

Will it be enough?

Even though the FIA welcomed the interest of Andretti and GM, the news provoked a notably lukewarm reception from Formula 1, the commercial rights holder, as well as betraying its current rift with the governing body.

An F1 statement said: "There is great interest in the F1 project at this time, with a number of conversations continuing that are not as visible as others." Those conversations are now known to have included Ford's tie-up with Red Bull as well as Porsche's enduring interest. Both trump the prospect of Cadillac badging an existing Renault engine.

Cadillac has not ruled out taking a greater role itself once the project begins. "Our commitment to this program goes beyond the Cadillac livery," stressed Reuss. "GM's vast engineering resources will bring proven success and valuable contributions to this partnership. This includes all the talent and capabilities of GM racing staff and facilities in Michigan, at the Warren Tech Center and North Carolina, as well as the expertise of our engineers and designers in the areas like combustion, battery technology, turbocharging, vehicle integration, and the list goes on and on."

GM has a pre-existing relationship with Honda – currently supporting Red Bull in F1, but also a potential entrant itself in 2026 – relating to electric vehicles. That deal does not preclude the two manufacturers racing against each other, as has been the case in IndyCar.

GM's current campaign in IndyCar, where Chevrolet competes against Honda, is not jeopardised by a potential F1 entry, a spokesperson said.

Although the F1 deal was instigated by Andretti, Reuss did confirm that it had been GM's ambition to one day become involved in F1.

"At some point, General Motors during the history of, at least in my career, we would have loved to have gotten into Formula 1. But for various reasons, it was pretty tough to do that," he said. "Whether it was the leadership or the amount of money at that time, or where the company was, where the economy was, whatever those reasons were, over a long period of time, they were different. But I would say this opportunity, and Michael (Andretti), was just really, really important to us.

"So I would say, we weren't searching necessarily to do it. But Michael kicked it off. And I personally was really over the moon."

Although Andretti is currently working on a new headquarters for its racing projects in Indiana, the F1 squad will also operate from a support facility in Europe. RT

Formula E

BELOW Andretti's Formula E team won the first race of the Gen3 era

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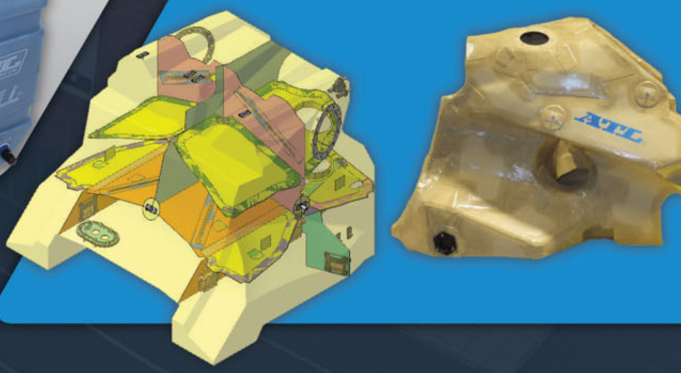

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ABOVE Acura won a third consecutive Rolex 24 as the GTP class made an unexpectedly smooth debut

Acura ushers in hybrid GTP era with third successive Rolex 24 win

THE electrified IMSA GTP sportscar racing era got underway successfully at Daytona International Speedway last month. The introduction of the hybrid LMDh cars meant everything was different – except the result: Acura secured its third consecutive Rolex 24 win in the crown jewel of North American endurance racing.

This was the first race outing for the Acura ARX-06, which faced GTP opposition from Cadillac, Porsche and BMW. But, remarkably, Meyer Shank Racing and Wayne Taylor Racing with Andretti Autosport repeated 2022's 1-2 sweep of the 24-hour classic.

It was, perhaps, an unexpectedly smooth debut of the GTP class. After roughly 18 months to build their hybrid prototypes, eight of the nine GTPs were running at the end of 24 hours.

"Winning is unbelievable, to be honest," reflected David Salters, President, Honda Performance Development, on the triumph by Acura and Meyer Shank Racing. "This program involves a lot of people, all of whom work really, really, really hard to do this. So the real privilege is to work with those people, and achieve days like today. And it doesn't happen all the time. So when it does pay off, it's all the more special.

"In the two years [it took to design, build and develop the Acura ARX-06], I think it's the best thing I've been involved in. So well done everyone at Acura Motorsports, Honda Performance Development, ORECA, Meyer Shank Racing and Wayne Taylor Racing with Andretti Autosport. If this weekend was not a demonstration of 'Precision Crafted Performance', I don't know what is.

"This game is not rocket science, it's getting the right people, in the right places, and letting them do their job. So, 'is it worth it'? Oh, hell yes. And it's because of the people you get to share it with."

The short development timeline for the new cars, which featured a hybrid drivetrain developed with Bosch, WAE Technologies and Xtrac, was always going to be tested to the limit and beyond by the 24-hour challenge.

Post-race, Shank revealed that from lap 200 – around the six-hour mark – the lead car had been suffering with an overheating gearbox.

Although both of its Porsche Penske Racing 963 GTP cars led laps on its debut, only one car finished the race, 34 laps behind the winner, after a lengthy delay to replace its energy storage system. The other entry was in contention for the win until Sunday morning, when it retired with a broken gearbox.

While Porsche promised to "learn quickly", BMW team boss Bobby Rahal described getting the two new M Hybrid V8 LMDh prototypes to the finish on debut as "almost like a win". Both cars had suffered significant delays on the way to sixth and ninth.

Cadillac, which finished third, fourth and fifth, had a strong race, though the third-placed car had recovered from two laps down after an unscheduled stop to replace rear bodywork when it was tagged by an LMP3 car.

An 89 percent finishing rate would be an outstanding record for any class in any 24-hour race, let alone one featuring such complex vehicles in their competition debut. RT

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Ford
Multimatic
GT Mk IV
MICHELIN

Ford goes all-in with new GT Mk IV

ABOVE Production will be limited to 67 hand-built supercars – a number honouring the original 1967 GT Mk IV race car

FORD Performance and Multimatic have revealed the Ford GT Mk IV, billed as the ultimate and most extreme track-only Ford GT ever.

To deliver unconstrained performance, exceeding that of any Ford GT to date, the Ford GT Mk IV has a unique twin-turbo EcoBoost engine, targeting more than 800 horsepower. It features a racing transmission, carbon fibre 'long tail' body, plus Multimatic's Adaptive Spool Valve (ASV) suspension.

"The original GT Mk IV held nothing back for max track performance, and the new Ford GT Mk IV brings it in the same way," said Mark Rushbrook, global director, Ford Performance Motorsports. "With an even higher-level of motorsport engineering and performance, plus a completely new carbon fibre body that is functional and striking, the Mk IV is the ultimate send-off of the third-generation supercar."

The new Ford GT Mk IV nods to the year that the original Mk IV won the 24 Hours of Le Mans, with just 67 of the hand-built supercars to be produced at Multimatic's facility in Markham, Ontario.

"Multimatic's brief was to create the most extreme final version of the Ford GT, and the Mk IV is the outcome," said Larry Holt, executive vice president, Multimatic Special Vehicle Operations Group. "A unique larger displacement engine, proper racing gearbox, stretched wheelbase and truly radical body has resulted in an unprecedented level of performance. We are proud to have been a part of the third-generation GT from its inception to this amazing swansong and consider it a significant chapter in Multimatic's history."

Tech advances

Building on Ford GT Mk II's triumphant 1966 1-2-3 Le Mans finish, Ford's development team held nothing back and redesigned the car from scratch with state-of-the-art technology and engineering available to create the 1967 Ford GT Mk IV.

To leverage new material science advantages, Ford's engineers and Kar Kraft developed a new lightweight chassis using adhesive bonded honeycombed-aluminium construction with a more aerodynamic body and named it the "J-Car" because it was built to the new FIA Appendix J rules.

Combined with the famous 427 Ford V8 (7L) engine and a special transaxle with its own cooling system that carried power to the rear wheels, the 1967 Ford GT Mk IV was nine inches longer and built specifically to dominate global endurance racing. RT

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PFC Brakes lands new INDYCAR deal

INDYCAR has renewed its contract with PFC Brakes. The South Carolina-based expert has been Official INDYCAR Brake Supplier since it introduced its V3 Disc and pad retraction technology to the series in 2016, an innovation that won the prestigious Borg Warner Louis Schwitzer Award.

The agreement renewal will see PFC Brakes supply the top-tier NTT INDYCAR SERIES but also the championship's feeder categories: the INDY NXT by Firestone, and the newly rebranded USF Pro Championships Presented by Cooper Tires, which is an evolution of the Road to Indy with its three categories. The deal amounts to five categories in total, featuring more than 100 single-seaters.

Mary Ann Burgoon, PFC Brakes CEO, commented: "Our team of design engineers works hard giving the best brakes to the INDYCAR SERIES. We are permanently improving in that area and sighting the new challenges such as the new Hybrid car. We are proud Official Brake Suppliers in all the INDYCAR SERIES, probably the best and the most competitive single-seater championship in the world!"

"I'm delighted to continue working with INDYCAR across a wide range of disciplines," commented Luis C. Maurel, Director of Global Motorsports, PFC Brakes. "We are all looking forward to the challenges posed by the forthcoming hybrid era, a task which the company's work on other electric racecars and supercars means we are well equipped to deal with."

BELOW With IndyCar about to go hybrid, PFC's work on EV braking systems should prove invaluable

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McLaren Applied appoints new Motorsport Director

McLAREN Applied has announced current Head of Motorsport Accounts, Richard Saxby, as its new Motorsport Director.

A motorsport veteran with over 20 years' experience in Formula 1, Saxby started his career as a Graduate Research and Development Engineer at Stewart Grand Prix. He has gone on to work with some of the sport's most illustrious names, including Renault F1, Red Bull Racing, and Mercedes AMG.

Employed across electronics, systems and testing and development applications, his efforts have spanned both trackside and factory-based positions, and contributed to a remarkable 10 constructors' championships.

ABOVE Saxby will head up Applied's Motorsport Business Unit

"I'm very happy that McLaren Applied has placed its confidence in me to lead such a talented team," said Saxby. "The brand's involvement at the cutting edge of motorsport is even lengthier than my own, and I look forward to continuing its mission to create a competitive advantage for partners through continuous technological innovation and consultancy."

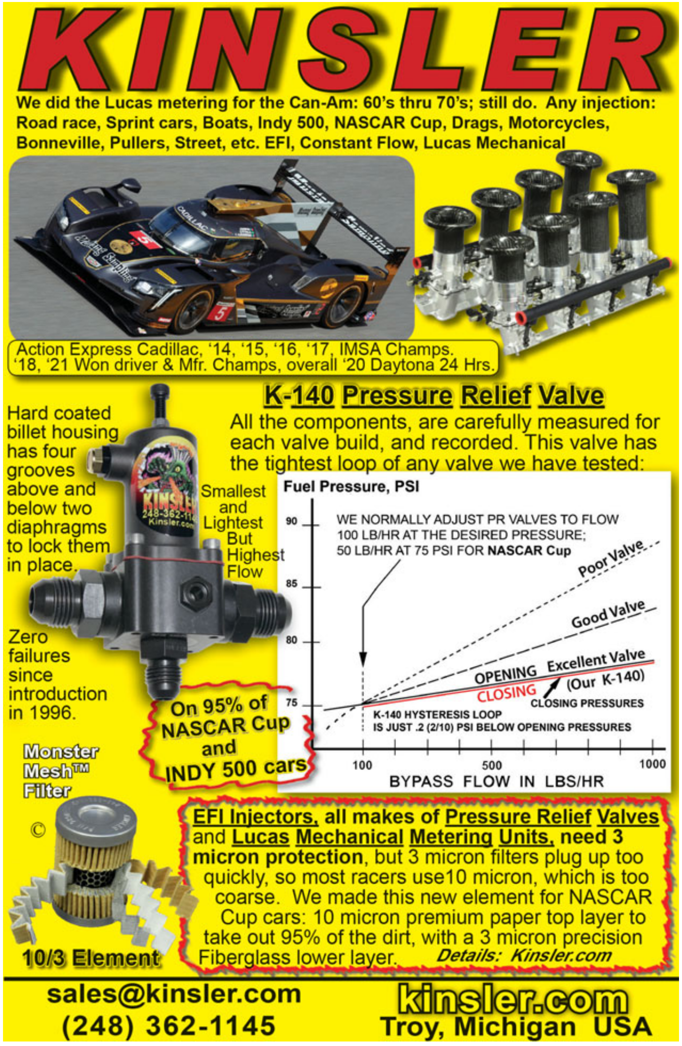
Since his arrival at McLaren Applied in 2021, Saxby has doubled down on the company's customer-based focus and recently assisted in winning the contract to provide the Standard ECU (SECU) to Formula 1 until at least 2030, in addition to existing agreements with NASCAR and IndyCar.

McLaren Applied has provided the SECU – a fundamental part of the Formula 1 electronic ecosystem – for every car on the grid since 2008. The new deal will extend the partnership into its 22nd year.

Announcing the appointment, Nick Fry, Chairman of McLaren Applied, said: "Since joining us in 2021, Richard has significantly improved our focus on meeting customer needs and has driven many business enhancement initiatives. He also made a valuable contribution to our successful SECU bid earlier this year.

"Now at the helm of the Motorsport Business Unit, Richard will continue our mission to become Motorsport's preferred partner for electronic systems, software and support."

Saxby replaces Matthias Dank, who has returned to his native Austria to re-join AVL as Executive Vice President.



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Williams Advanced Engineering re-branded as WAE Technologies Limited

WAE Technologies – formerly named Williams Advanced Engineering – has said goodbye to the Williams name, unveiling its new corporate branding and logo.

The move follows the acquisition of the world-leading technology and engineering services business by Fortescue, which completed in March 2022, taking the Oxfordshire-based company in a new direction.

Renowned for its ground-breaking projects in high performance battery systems and electrification, WAE Technologies was initially established in 2010, under the Williams Advanced Engineering name, as an offshoot of the Williams F1 team, founded by the revered, late Sir Frank Williams.

With the business being acquired in its entirety by Fortescue in early 2022, WAE's new focus has been to drive progress and combat climate change through advanced engineering and technology services, enabling Fortescue to become a major player in the growing global market for green industrial transport equipment. To mark this historical turning point, a new corporate identity has been launched.

WAE's battery technology is also a critical element of Fortescue's fully costed plan to achieve real zero by 2030, the first heavy industry company in the world to have such a plan.

WAE has previously operated under the Williams name - Williams Advanced Engineering - through a licence agreement as part of Williams F1 ownership. With the licence expiring in 2023, and a separation of the two companies with Fortescue's acquisition, WAE will no longer use the Williams Advanced Engineering name.

Moving forwards, the company will now be known as WAE Technologies Limited, with its subsidiary businesses sharing the WAE branding (WFT WAE Foresight Technologies and WAE Joint Ventures Limited). The 'WAE' will not stand for anything but will continue to be pronounced as individual letters 'W', 'A', 'E'.

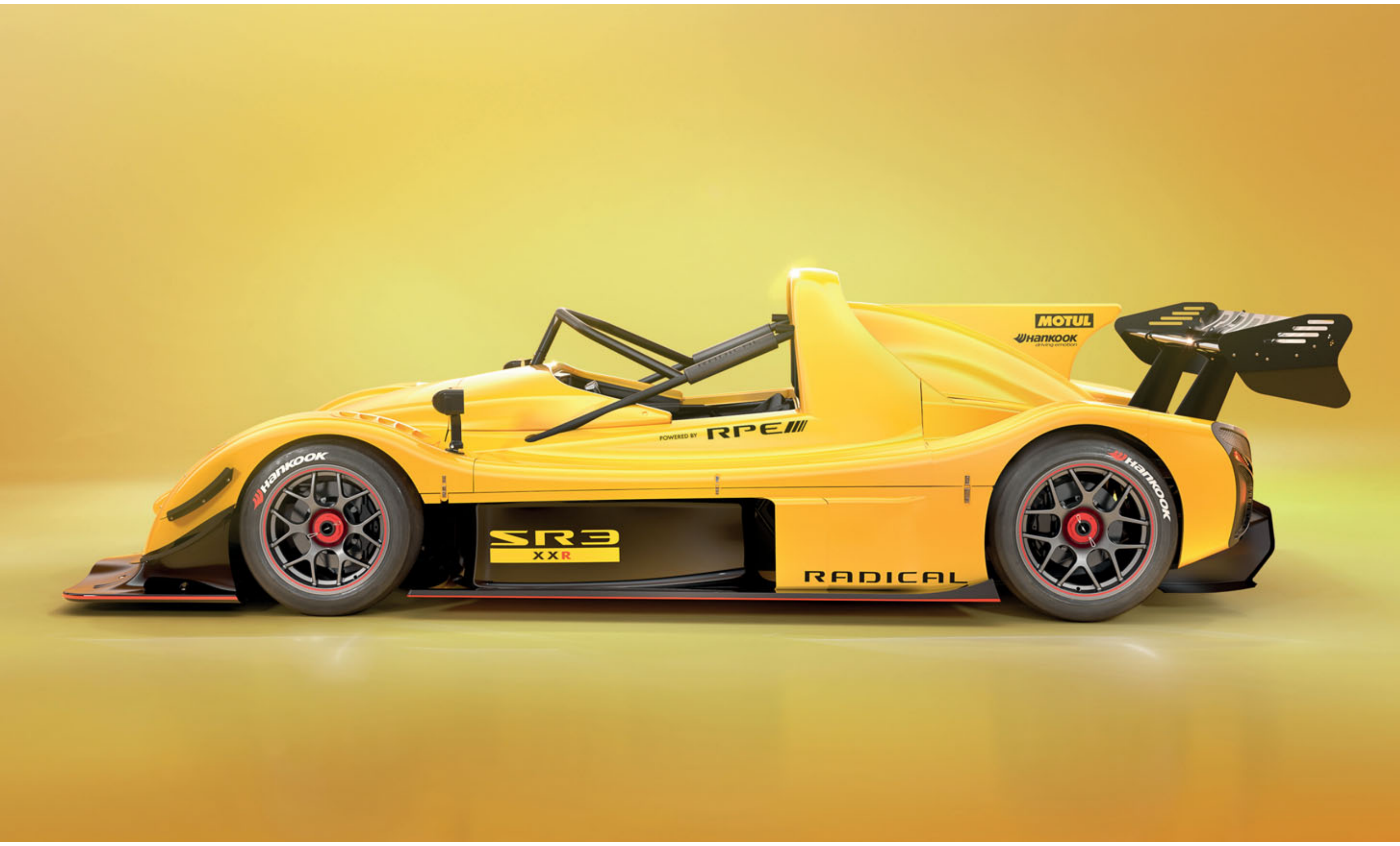
In line with the changes reflected in the company name, WAE Technologies has adopted all-new branding. Echoing the change of direction, the new logo incorporates a modern and innovative feel. The name 'WAE' becomes the centrepiece of the new logo, with a contemporary typeface that evokes a futuristic feel.

Commenting, WAE Technologies CEO Craig Wilson said: "We are now entering a new phase in the company's growth plans and the time is appropriate for a new name and branding which reflects our position as a leading, stand-alone business. Under the stewardship of Fortescue, our mission is to drive progress and combat climate change through next-gen technology. We want to take this opportunity to thank Williams F1 for all its support over the years, as we move into the next exciting chapter as WAE Technologies." RT

BELOW The company's battery technology is central to Formula E's new Gen3 racecar

Formula E

LifeRacing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Radical reveals SR3 XXR

RADICAL Motorsport has unveiled the full specification of its all-new SR3 XXR.

Enhancing the proven formula of the SR3, the UK-based motorsport firm has focused on performance, usability and durability while retaining the essence of what makes the SR3 the most successful prototype-style sports racing car in the world.

SR3 models currently make up the majority of grids in the 12 Radical Cup championships around the world, with over 1,500 sold to date. The team behind the SR3 has upgraded the model, which is now available in SR3 XXR guise.

The major change is the all-new engine from in-house Radical Performance Engines (RPE). Delivering 232 bhp from the revised 1,500 cc unit, the lightweight SR3 XXR is expected to maintain its impressive power-to-weight ratio exceeding 350 hp per tonne. The use of the Generation 5 engine makes the SR3 XXR the first Radical that can run on biofuel.

Delivering on customer feedback, the SR3 XXR has been modified to be more agile on track, especially in crucial pit lane stages in which saving time, while not being penalised for speeding, is pivotal. With a new pit limiter fitted as standard, the chance of being punished for speeding through the pit lane is eliminated.

The LMP-inspired central tail ‘shark fin’ delivers notable aerodynamic improvement to entry and mid-corner stability. The SR3 XXR is also differentiated by its lightweight wheels in a new design alongside high-intensity DRL lights. A carbon fibre splitter and rear diffuser will be offered as an option to improve durability and aerodynamics on track.

Joe Anwyll, Radical Motorsport CEO, said: “This new car has been developed with valuable contributions from our dealer partners as well as current and past customers. For example, it is through listening to their experiences that we gathered they wanted a pit limiter to stop accidental speeding through the pit lane as well as the new cooling setup that significantly reduces warmup time. These factors are just examples of how we continue to enhance the enjoyment of the SR3, arguably the most loved racing car in the world.”

With the increased performance, the engineers at Radical Motorsport have utilised the new technical partnership for the SR3 XXR with AP Racing, to make an upgraded braking system available. The new solution has improved performance through a reduction in unsprung mass and improved pedal feel.

James Pinkerton, Radical Motorsport Head of Research and Development and double Radical Cup UK Champion, said: “The SR3’s handling is renowned as a masterpiece so for [SR3] XXR we took the approach of evolutionary improvements across multiple areas. We looked at customer feedback as well as a list of items we’d personally like as racers. We then set about scrutinising every system on the vehicle to see where improvements could be made, whilst staying true to the SR3 formula. We’ve carried over the sidepod profile from the SR10 to improve airflow and reduce turbulent drag, and of course the new Generation 5 RPE engine is undoubtedly the star of the show.”

There are a number of further improvements to the SR3 XXR’s powertrain. Notable changes include durability updates and external gear position sensors for the gearbox, a new scavenge pump design with improved flow for the oiling system and a fuel composition sensor that allows for the use of E85 biofuels. There has also been a complete rework of the engine and gearbox calibration, as well as improvements to the flow rate and flow consistency of the cylinder head.

Other enhancements include a reduction in mass for the connecting rods, crankshaft pins and the ignition system. While these increase the peak power and torque outputs without compromising durability, the improvements can be felt from 6,500 rpm all the way to 10,000 rpm.

SR3
XXR
RADICAL
RPE
Hankook
MOTUL

BELOW The first deliveries of the SR3 XXR are expected later this month

Lucid unveils motorsport Electric Drive Unit

SILICON Valley EV innovator Lucid has released details of its new electric drive unit for motorsports.

The unit recently made its race debut (currently in regen only format) on all the cars in the Formula E World Championship.

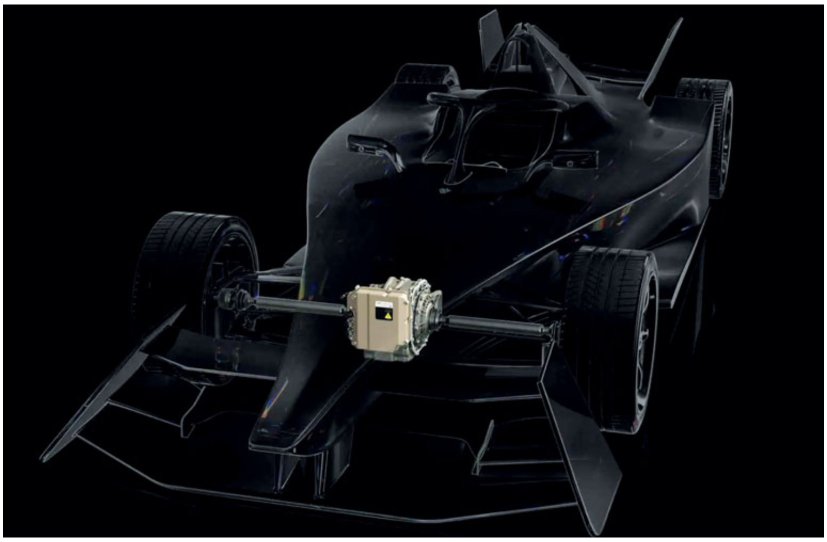
"With incredible power density of 14.7 hp/kg and immense energy recuperation, this drive unit will once again transform electric motorsports, following in the footsteps of our revolutionary battery pack in prior race seasons," said Peter Rawlinson, CEO and CTO, Lucid Group. "For Lucid, the transfer of technology between motorsports and road cars is a two-way symbiosis. This new motorsports drive unit builds directly upon the ground-breaking powertrain technology developed in-house by Lucid and proven on the road in every Lucid Air. I'm excited by the prospect that some of the technical advancements introduced may in turn make their way to future Lucid road cars."

Comprising motor, inverter, differential and transmission all combined, the new motorsports drive unit produces 469 horsepower – despite a weight of only 70.5 pounds (32 kilos) – and is capable of a max rotor speed of 19,500 rpm. It features the same state-of-the-art high-voltage continuous wave winding and proprietary microjet cooling system that can be found in the motors powering the Lucid Air sports sedan.

Positioned in the nosecone of every racecar in the current Formula E World Championship, the new Lucid drive unit provides regenerative energy recovery from the front wheels under braking, significantly enhancing the racecar's performance envelope, efficiency, and relevance to road car advancement.

Just as the motors in the acclaimed Lucid Air sports sedan are designed, engineered, and produced entirely in-house by Lucid, the new motorsports front drive unit is completely proprietary. Lucid drew upon its expertise of e-motor design, power electronics, computer simulation, and design engineering to create this cutting-edge drive unit. Each motorsport drive unit is manufactured to exacting specification in Lucid's headquarters in California. RT

BELOW The EDU is already proving itself in Formula E



All F1 drivers to have helmet cameras

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ABOVE The new camera angle has been widely praised during trials

HELMET camera technology is to be rolled out to all drivers on the grid for the 2023 Formula 1 championship, as the result of an agreement between the sport and Racing Force Group.

The new cameras were trialled by selected drivers during the last two seasons, with Fernando Alonso first to try it out in the 2021 Belgian Grand Prix. The resulting footage was widely praised by viewers to the world feed.

It will now become standard equipment for all competitors if they want it after the FIA mandated it for 2023.

One of the problems was that early versions of 'helmet cam' systems provided an unsteady picture because of the speed the car was going over bumpy circuits, but the new system managed to successfully mitigate against this.

The helmet camera has been trade marked as 'The Driver's Eye'. The FIA-homologated micro camera (8 millimetres in diameter and weighing 2.5 grams) is positioned at eye-level on the protective padding on the inside of the driver's helmet. RT

OPEN MIND, OPEN ROADS?

What did we learn from the inaugural WRC Innovation Forum? **Anthony Peacock** reports

LAST year's Monte Carlo Rally opened up a brand new chapter for the sport, with the most far-reaching set of fresh regulations introduced since the World Rally Car formula made its debut in 1997. So this year's Monte had a lot to live up to in terms of innovation: while there were some new faces (notably with Cyril Abiteboul at Hyundai), the rally action itself was more a reminder of times past. By the end of Friday, Sebastien Ogier was more than half a minute ahead of everyone else, en route to a record-breaking ninth win in the principality.

Meanwhile, the WRC Innovation Forum took place, designed to showcase the next chapter and presented by various luminaries of the sport, including WRC Promoter Managing Director Jona Siebel, Hyundai's Head of Powertrain and Future Technologies Julien Moncet, Toyota Team Principal (and former driver) Jari-Matti Latvala, and Martin Popilka, the CEO of P1 Racing Fuels.

Topics included 'rethinking the future of powertrains', 'WRC as an innovation hub', 'achieving low-carbon mobility' and 'innovation in action' – but the over-arching themes were broadly similar: how to make rallying more environmentally-friendly and relevant to road-going production. In the end, the mantra of 'win on Sunday, sell on Monday' is as relevant as it has ever been. You just have to hug a few trees along the way now in order to do so.

It's easy to be cynical, especially after you see cars being warmed up at various revs in the Monaco harbourside service park just before making a mandatory electric glide up the hill to the ceremonial start at Casino Square.

But a start has to be made somewhere. And those of us who first saw the Citroen C4 WRC HYmotion 4

CASINO MONTE-CARLO
2023 91e 2023
RALLYE MONTE-CARLO
WRC
LE CASINO

Red Bull/WRC

WRC as an Innovation Hub
Advancing technology in real conditions for greater impact
Panel Discussion
Peter Thul – Senior Director Sport, WRC Promoter – Introductory Presentation
Eleonora Giada Pessina – Group Sustainability & Diversity Officer, Pirelli & C S.p.A
Richard Millener – Team Principal, M-Sport Ford World Rally Team
Jari-Matti Latvala – Team Principal, Toyota Gazoo Racing World Rally Team
Luca Uguzzoni – Senior Sustainability Business Development Manager, SEL – Sport & Event Logistics
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OCIHYFUELS

Red Bull/WRC

ABOVE Following the success of the panel in Monte Carlo, the WRC Promoter is planning future forums in the upcoming season

LEFT The silent glide to the ceremonial start of the Monte in Casino Square, following a lengthy ICE warm-up process, betrayed a conflict

concept car demonstrated back in 2008 and scoffed – I was one of them – are now being forced to eat their words.

At the time, I thought the whole thing was ridiculous, but I should have thought back to the very beginning of the 1990s, when I was at university. Every Friday, a few resident nerds would close themselves behind a door marked ‘computer club’ and remain there until the early hours of Saturday, more or less when my friend Dan and I would be returning from an evening of heavy drinking.

Seamless innovation

“So what is it exactly that they do in there?” I slurred to Dan once. He patiently explained that they were looking at a thing called “the web”, which he said was a bit like going to the library, but instead of picking out a book by hand to find information, the information appeared in front of you on a screen. He added that they also communicated using “e-mail”; a bit like opening a letter, but on screen instead of paper. I considered this intelligence carefully. “Nah,” I concluded. “That’s never going to work…”

There’s a moral in this story. Perhaps the biggest technological revolution of the latest WRC regulations was the adoption of 100% biofuel last year, courtesy of official suppliers P1 Racing Fuels. This fossil-free hydrocarbon-based fuel was the first of its kind to be used in an FIA world championship but nobody would ever know, as there is zero effect on performance, aesthetics, or reliability (although engine mapping has to be tweaked).

> *“‘Win on Sunday, sell on Monday’ is as relevant as ever. You just have to hug a few trees along the way now”*

The fact that nobody really noticed this huge innovation was perhaps the biggest compliment that could be paid; a sign of the normalisation of what were previously known as ‘eco technologies’.

Toyota, for example, won’t even badge some of its cars as “hybrid” – as hybrid technology is now taken for granted.

Monaco was an appropriate place to host the Innovation Forum, because the principality aims to ▶

be entirely carbon neutral by 2050, and you can already recharge your electric car for free there.

But the fact is that thermally-powered cars will be around for decades (even if and when they are no longer sold; new car sales constitute only one-twentieth of total owned vehicles) and there are also many territories visited by the WRC (notably Kenya) where electric mobility is a distant prospect, so manufacturers still need to showcase their internal combustion products. "Mobility for all" is how Toyota describes their philosophy, with the message coming down from the top being that nobody should be left out.

Furthermore, although electric rally cars (such as the Opel Corsa) currently exist, there's no way that they could cope with the actual format of a WRC event. The current cycle of regulations is in place until 2025, when the next set of rules – set to be announced very shortly – will be an evolution of today's Rally1 specification, except with a bigger hybrid element, longer EV modes, and more promotion of sustainable fuel.

Those rules will be in place until the late 2020s – with the hope of attracting more manufacturers into the sport – but by 2030 (according to the KPMG global automotive survey) most markets will still have only around 50% of new car sales that are purely electric.

So it's clear that any new WRC rules will have to be flexible enough to adapt to a rapidly-changing situation and appeal to manufacturers, without compromising the visceral thrill that's

> *"Engaging with communities is as integral to the WRC's sustainability plan as any technological measures"*

synonymous with the WRC.

By nature, rallying runs through the heart of spectacular natural landscapes and that's probably where the opportunity lies, as shown by Extreme E for example. You can't compare this short off-road electric formula to WRC, but there are some important parallels and lessons to be learned, with different sustainability programmes promoted within both championships.

Natural rubber

We've spoken already about biofuel, and even the Pirelli tyres currently used in the WRC come from sustainable natural rubber – part of a programme designed to help local farming communities as well as the planet as a whole. Pirelli prides itself on having 95% of its procured natural rubber coming from suppliers that are audited on-site according to the company's sustainable natural rubber policy – with Pirelli also launching the first FSC-certified (Forest Stewardship Council) road car tyre a couple of years ago.

Citroën

ABOVE Citroën pioneered a hybrid rally car concept as far back as 2008. Nah, that will never catch on…

Red Bull/WRC

LEFT P1 Racing Fuels revealed that the very same fuel researched and developed for the punishing WRC stages will now see everyday use in a fleet of German governmental vehicles in Berlin

Engaging with communities to promote humanitarian causes is as integral to the WRC's overall sustainability plan as any technological measures.

Because it's obvious that there is no silver bullet and no fast answers. The drawbacks of purely electrical mobility are well known, and the increasing consensus among experts is that electric power will only be an interim solution, with the final answer perhaps lying elsewhere, such as hydrogen or methanol. Not to mention, of course, biofuels: the route that the World Endurance Championship has gone down as well.

So far, the new Rally1 formula has resulted in a win for each of the competing manufacturers, with a wide range of models based on cars from the B-segment (Toyota Yaris), C-=segment (Hyundai i20), and SUV crossover (Ford Puma) families. But there are still only three of them.

So to drive innovation in the sport, first the sport has to listen to the needs of the manufacturers, and therefore the global car industry as a whole. From there, the way forward will be clear. An open mind will lead to open roads.

"You look like a real idiot if the car breaks when you've got an hour's lead"

Toyota GAZOO Racing was hunted down by rivals from the early stages of this year's Dakar Rally. **Chris Pickering** discovers what was going on behind the scenes from TGR Dakar Team Principal Glyn Hall

Red Bull
TOYOTA
GR
HC 68 WP GP
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SAUDI ARABIA

EVEN by the standards of the world's toughest race, the 2023 Dakar Rally was a monster. This is motorsport on a truly epic scale, with 4,706 km (2,924 miles) of special stages spread across a total distance of 8,549 km (5,312 miles).

That's the equivalent of racing across the full width of the United States. Twice.

But what made this year's event stand out was the severity of the conditions. Vast sand dunes – bigger and more frequent than those of recent years – to test the suspension and powertrain to the limit; biblical floods that turned some stages into swamps and caused others to be cancelled altogether; and huge boulders, supposedly uncovered by the extreme weather conditions. Dakar veterans described it as a comparable challenge to the original events in the Sahara.

On top of that, there were perhaps 12 cars that had a realistic chance of winning the premier T1 categories. Take a look at the timesheets and it might appear that Nasser Al-Attiyah and co-driver Mathieu Baumel cruised to a comfortable victory in their Toyota Hilux. But the reality is that a single slip could have put them back into the clutches of the chasing pack, with Prodrive's Sébastien Loeb and Fabian Lurquin capturing a record-breaking six consecutive stage wins in hot pursuit.

The current Toyota GR DKR Hilux was launched last year, but its roots stretch back over a decade. Hallspeed – now known as Toyota Gazoo Racing South Africa – began building rally raid Hiluxes ▶

Red Bull

ABOVE & LEFT Qatar's Nasser Al-Attiyah and his French co-driver, Mathieu Baumel, successfully defended their Dakar title for Toyota GAZOO Racing

near the old Kyalami grand prix circuit in 2011. The first cars used a spaceframe chassis with beam axle rear suspension, four-wheel drive and a naturally aspirated Toyota '1UR' V8 mounted in the front.

In 2016, the company built a two-wheel drive mid-engined buggy known as the Hilux Evo. This had shown promise in testing, but rule changes in the Dakar soon rendered it obsolete. With that in mind, company director Glyn Hall decided to build a mid-engined four-wheel drive car, taking elements of the design philosophy from the buggy. Launched ahead of the 2018 Dakar, it was known as the Hilux IMA (short for Independent, Mid-Engine, All-Wheel Drive).

Around this time, Peugeot was looking into the possibility of extending its Dakar programme, and was reputedly lobbying the organisers to allow four-wheel drive cars to run with the larger wheels found on the buggies. In the end, the French brand withdrew from the category, but the seed had been sown for what would later become the T1+ regulations.

"In parallel to the development of the IMA, a small group of us put together a set of proposed regulations based around a larger 35-inch tyre. That didn't come to fruition at the time, but we designed the IMA partly with those regulations in mind," recalls Hall.

The Hilux IMA proved competitive on its first Dakar outing in 2018, with two cars finishing in the top three. A year later, Al-Attiyah and Baumel took Toyota's first ever Dakar win in what was to be the final South American running of the event.

The move to Saudi Arabia in 2020 proved popular, but the four-wheel drive cars on their smaller 32-inch tyres suffered horrendously from punctures, Hall recalls: "You get a lot of sharp flints in Saudi Arabia that were tearing the tyres to shreds, and I said to the FIA, 'We can't carry on like this; all the 4X4 manufacturers will just leave'."

Performance parity with the two-wheel drive buggies remained a thorny issue too. Ironically, it took the arrival of the Audi RS Q e-tron to sort things out. The German manufacturer had negotiated a string of concessions for its hugely sophisticated hybrid entry, including greater track width, increased suspension travel and the larger wheels used on the buggies.

As soon as it became clear that this car would be eligible to compete for overall victory, it gave the T1 4X4 manufacturers the argument they needed to press for the same concessions. As a direct result of this, the chassis regulations for T1 4X4s were effectively brought up to the same standard, and the T1+ class was born.

New engine

Part of the deal was that Hallspeed could convert its existing V8 T1 cars to T1+ spec, which it did, with no less than eight customer cars converted for the

RIGHT The GR DKR Hilux T1+ seized control from the third stage, going on to win by 1hr 20 min 49 sec

BELOW The V35A base engine, seen here in the workshop, is taken straight from the Toyota production line, with no internal modifications whatsoever

Photos: Red Bull

2022 event. Toyota, however, was keen to showcase the 3.5-litre twin turbocharged V6 that was going to be used in the new Land Cruiser 300 GR Sport, so it was also decided to press ahead with a new version of the racecar using this engine.

The V6-powered GR DKR Hilux T1+ made its debut on the 2022 Dakar and immediately sealed its reputation with a win, while a privately-entered V8 came third. Over the course of 2022, the new car was put through a further 25,000 km of racing and testing in both the World Rally-Raid Championship (W2RC) and the South African Rally-Raid Championship (SARRC). A series of refinements were made to the package during this time, largely focusing on reliability, but the core design has been carried over to 2023.

> *"We're doing 10,000 km, which is like four years of WRC in one go"*

The V35A base engine is taken straight from the Toyota production line, with no internal modifications whatsoever. It's fed by two production turbochargers and a standard intercooler rotated by 90 degrees, feeding into the standard intake manifold. The most significant modification is the switch to a MoTeC competition ECU, which works with the standard injectors and ignition system.

"The rules effectively led us to a target of 400 hp when we introduced the V6," comments Hall. "The engine does have to work quite hard if you're doing that all day, but it's within the normal operating parameters of a 3.5-litre twin turbo V6. This engine produces 415 hp in production form, so we knew it should be okay if we could keep the intake temperature and the oil temperature correct and keep the oil next to the sump pick up."

Making a wet sump work

T1+ cars are imposing beasts that sit at the best part of two metres high. Nonetheless, designers strive to get the centre of gravity as low as possible to improve handling and stability. A lot of manufacturers opt for dry sump systems to help drop the engine down, but Toyota has stuck with a wet sump arrangement, albeit in modified form.

"A dry sump is far more complicated for a privateer team when we sell the cars, so we put a big effort into making the wet sump work well," says Hall. "The sump has to hold the engine and the chassis as well as containing the oil and the bracketry to all the ancillaries. It sounds simple, but we're doing 10,000 km, which is like four years of WRC in one go, so it has to be properly engineered."

One of the few areas of freedom permitted in the ▶

T1+ engine regulations is the intake manifold – the design of which is effectively free providing it fits within a given volume. Toyota, however, elected to stick with the standard production design.

"The engines go to the dyno at the FIA in Geneva, and they all get a boost curve attributed to them to fit to a standardised power curve. So, within reason, if you've got the basics right you shouldn't really need a custom manifold from a performance standpoint," comments Hall.

This process is generally acknowledged as the best way to balance the increasingly diverse powertrain technologies found in the category, but it's not without its challenges.

"This year, all the T1+ and T1U cars had a 30 kW power reduction, but that was based on a calculated boost curve, not the actual one from the dyno," Hall points out. "Last year with 296 kW we were happy, but for the reduced output of 266 kW this year we lost 6.5 per cent more boost pressure than the Prodrive car, so we need to go back to the dyno to re-evaluate.

Hallspeed put enormous amounts of work in when it originally did the V8, with two engine dynos working flat out in-house, Hall recalls: "We looked at hundreds of power curves with different restrictors, different exhausts, different intake manifolds and three different sump designs. That gave us the best V8 engine by far, but these days [with the standardised power curve] it's more of a plug and play exercise."

Nonetheless, the devil is in the detail. The boost pressure is measured to ±10 millibars, which is around a tenth of the level that human lungs can exert. Deviate from that at all, and the engine won't reach its optimum performance.

Built to last

The team was pleased with the performance and durability shown by the car in 2022. Nonetheless, Hall and his colleagues didn't want to take any chances.

"We wanted to make sure that the drivers could push the limit day after day if we were caught in a big fight. That included suspension, transmission and chassis durability," he recalls. "And it's just as ▶

BELOW Who said motorsport was glamorous? Preventative maintenance was essential to the gameplan

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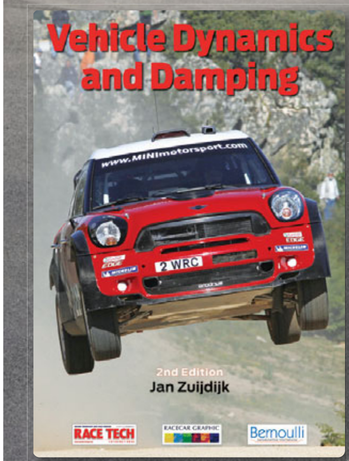

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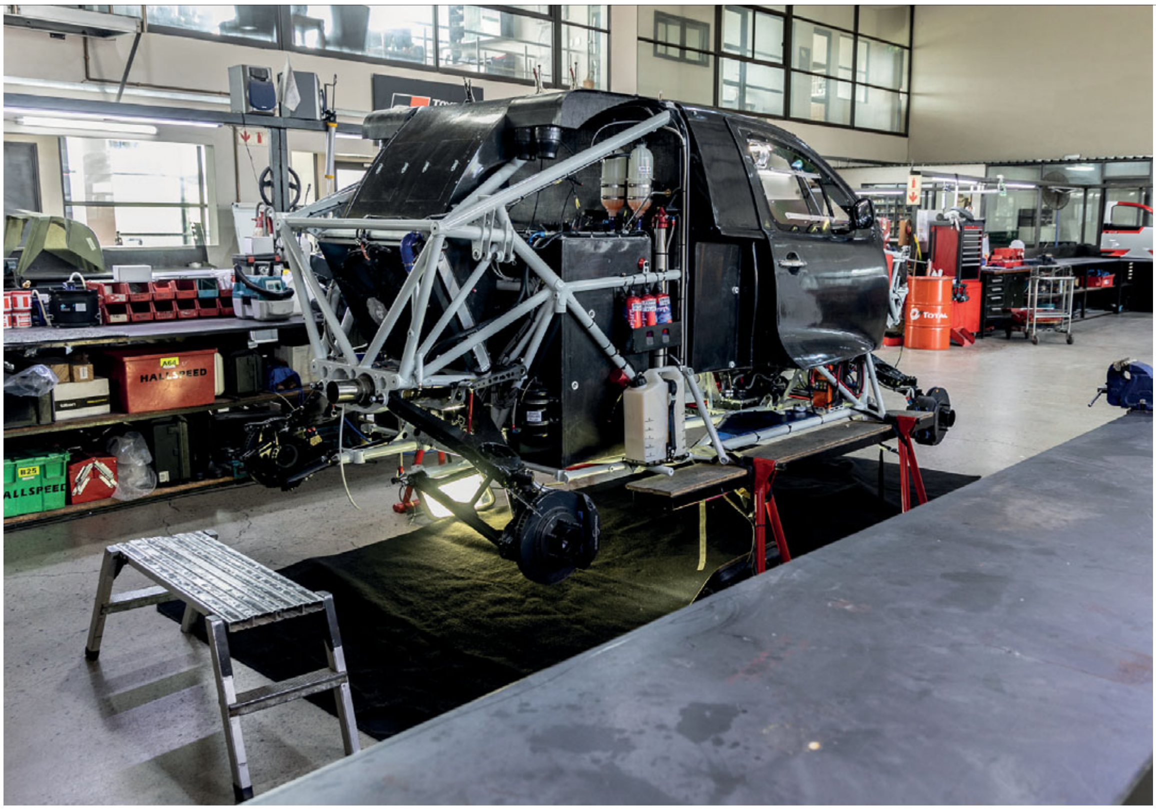

LEFT The Toyota GR DKR Hilux being readied in the workshop. This year the team was better prepared than ever before

> *“The sweet spot between durability, off-road capability and outright speed”*

well we did, because we were flat-out for most of the event. Initially, we held back slightly but Nasser [Al-Attiyah] was a bit uncomfortable, so we said, ‘It’s okay, you can go… we’ll keep changing the parts on the original schedule and you can turn it up a bit,’ and he was much happier then.”

Controlling the pace from the front is an enviable position to be in, but it can be a double-edged sword, Hall points out: “You have to remember it was our race to lose from Day Three onwards. You look like a real idiot if the car breaks when you’ve got an hour’s lead, so it’s a very stressful time.”

Standard servicing included changing the driveshafts twice during the 16-day event, along with precautionary changes on the hubs, wheel bearings and gearbox.

200 shim combinations

“Even by rally raid standards, the Dakar is huge,” comments Hall. “It’s the equivalent of seven or eight national championship races in one go. So we took plenty of parts to change simply as preventative maintenance.”

Prior to the rally, there was also a lot of work on suspension tuning. The team trialled more than 200 different shim combinations, working in partnership with damper supplier Reiger. In an ideal world, the aim is to find a shim configuration that strikes the perfect balance between handling, off-road ability and crew comfort (to reduce fatigue). Once the best compromise has been found, the engineers would generally just add or subtract clicks on the dampers to adjust for the changing fuel load each day.

“The Dakar is incredibly hard on dampers – they really work hard,” says Hall. “We had a small issue with two of the dampers, but Reiger reacted really quickly. They made some new parts and got them out to us so we were able to fit them on the rest day. Aside from that, we didn’t make any changes besides the usual clicks.”

Powertrain durability is less of a concern with the relatively low-stressed engines used by the T1+ competitors. Nonetheless, the cars spent considerably more time at wide-open throttle during the early stages of this event than they did last year, which Hall attributes to the power reductions and the long desert sections.

“It’ll be interesting to see what comes out in the driver’s survey,” he reflects. “The feedback from last year was that ▶

Red Bull

BELOW Desert duel: This is as near as you get to a close overtaking manoeuvre in an event running for 45 competitive hours. Al-Attiyah fights with a privately-entered Toyota Hilux T1+ in the hands of the young Brazilian, Lucas Moraes, who finished third on his first attempt at the Dakar Rally

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they wanted to take [the challenge] up a notch, but I think they went a bit too far. Our drivers felt there were too many repetitive dunes and not enough gravel sections, but it's a very difficult balance to strike."

Equivalence

The Dakar has employed an equivalence of technology (EoT) process since the arrival of the T1U class and Audi's series hybrid RS Q e-tron last year. This isn't intended to balance the performance of the cars as such, but rather to remove any fundamental advantages or handicaps posed by the various powertrain technologies.

There was a degree of controversy this year when Audi (the sole T1U team) was awarded an 8 kW (11 hp) power increase. The announcement came ahead of Stage 5, with Audi having won two stages (including the Prologue) to Toyota's one and Prodrive's two. In the heat of the moment, Al-Attiyah took to Instagram, where he posted a photo of the statement with a caption that it was "killing the race". He later apologised, explaining that he now understood the decision more thoroughly, but the outburst reflects some very real fears among the T1+ competitors.

"We were massively concerned, because the Audi's package is quite a complicated one," comments Hall. "They don't have gear changes, which is a big advantage; they have separate motors driving each axle, which effectively gives them an active centre differential; and although their maximum power output is balanced to ours, they have access to that the whole time, whereas our 266 kW is a peak value that actually averages out to something like 253 kW across the whole gearchange window."

The further down the rev range you go, the bigger this disparity becomes, he points out: "Our cars are accelerating optimally between, say, 5,400 rpm and 6,000 rpm. Below 4,500 rpm, the Audi's torque advantage starts increasing almost as an inverse square.

"Let's say you punch the throttle at 3,000 rpm going over a dune, we've got 600 Nm but the Audi has 900 Nm, if you extrapolate the curve and convert it from power to torque. And that's not just an academic point – when you look back at the data, we spent one hour at full throttle below 4,500 rpm."

The EoT process is intended to adjust for exactly this kind of issue, but it's by no means perfect. "The EoT is based on straight-line acceleration between 70 kph and 150 kph. So below 70 kph they're virtually free to use as much power as they want, and remember they've got a 600 hp DTM engine in there," comments Hall. "And the adjustment is based on the best-accelerating T1+ car, not the whole of the field. It's no secret that's the Prodrive car, and it means the other T1+ cars are further behind in comparison. The drivers who got close to the Audis reckoned they were already faster than the T1+ cars, so when they were given an extra 8 kW we were a bit taken aback."

It could be argued that Hallspeed with its classic rally raid design and a wealth of customer teams alongside the works effort represents the opposite end of the Dakar spectrum to the high-tech Audi. Hall is open about his admiration for the German engineers' achievements, but questions how relevant they are to the Dakar.

"It's amazing from an engineering point of view. I'm very impressed by the technology and the challenges that

Toyota GAZOO Racing

LEFT Al-Attiyah lambasted an early change in the Equivalence of Technology for one of Toyota's rivals. He later apologised, but the outburst betrayed fears that more conventional technology would be outgunned

> *"The feedback from last year was that they wanted to take the challenge up a notch, but I think they went a bit too far"*

Toyota GAZOO Racing

ABOVE The durability of the Sadev transmission was a contributory factor to the team's bullet-proof reliability

they've taken on," he comments. "But, speaking personally, I'm not convinced it's where the spirit of the Dakar really lies. This race wouldn't happen without the privateers, and I think we need to keep it simple. We're sustainable in the sense that we'll still be here when they've proven their technology and gone home."

Controversial

The DTM-sourced race engine that drives the generator unit in the Audi is another bone of contention, with the T1+ competitors using largely-standard production units. The engine alone is rumoured to cost close to half a million euros.

Overall, Hall believes a more conventional platform would work better for competitors, and could satisfy the sustainability requirements too: "For the future, I think sustainable fuels are probably a better solution. There has been some discussion on a new category to showcase new technology with limited stage mileage and a separate trophy. And I think that's probably the way to go."

He's also open to the idea of some level of hybridisation, but notes that it would need to be carefully balanced with costs.

Hydrogen is another key area of interest. Last year, French firm Gaussin successfully demonstrated a fuel cell-powered truck, while GCK (fuel cell) and ORECA (ICE H2) are working on potential hydrogen projects. It's also an area that Hall and his colleagues have looked into, running a range of simulations – FCEV, ICE H2, BEV – to judge which technology could be best suitable to meet the T1U range target of 250 km in the future.

In parallel to that, Toyota's motorsport department in Japan has actively competed with both hydrogen combustion and sustainable gasoline. Meanwhile, the Japanese giant has also collaborated with Yamaha to build a hydrogen-burning version of the 5-litre V8 found in the previous generation of the Dakar car. It's clear, then, that Toyota won't be short of options when elite competitors in the Dakar are required to switch over to sustainable technologies.

For now, though, the focus returns to the W2RC. Last year, Al-Attiyah and Baumel carried their momentum through from the Dakar, scooping the drivers' and co-drivers' championships, along with the manufacturers' crown for Toyota. They're well-placed to defend those titles, with an experienced team and a car that seems to find the sweet spot between durability, off-road capability and outright speed. But, as with the Dakar itself, you can guarantee it won't be easy. RT

BELOW Nasser Al-Attiyah celebrates with team principal Glyn Hall

"WE DIDN'T SUDDENLY TAKE AN IDIOT PILL!"

The key tech figures in the Mercedes-AMG Petronas Formula One Team reveal more about their nightmare season. By **Mark Skewis**

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WHEN the Mercedes-AMG Petronas Formula One Team launched its ‘zero-sidepod’ W13 at Bahrain last year, it provoked looks of incredulity.

F1’s aero group, responsible for shaping the new regulations, had simulated wildcard solutions that the teams might attempt in response to the aerodynamic overhaul of the regulations – but they hadn’t seen that one coming!

Yet rivals’ fears and astonishment quickly turned to glee when the cars hit the racetrack. The W13’s pace was modest, at best, and to quote Mercedes-AMG F1 Team Principal and CEO Toto Wolff, “It bounced like a rabbit”! None of the team’s sophisticated tools had predicted that porpoising would result from its extreme quest for ground effect aero performance. The champions’ pursuit of a ninth consecutive Constructors’ title was doomed from the start.

Twelve months on, as we enter launch season, there is once more a sense of trepidation in the air as we await a W14 we know will pursue a different aero philosophy. Niki Lauda, for so long a key member of Merc’s inner circle, had always insisted to colleagues that they would only discover how good they truly were when things went wrong. Now they have done – and 2023 could be payback time.

What went wrong?

Undisputed kings of F1’s hybrid era, Mercedes appreciated that one day it would be ousted from the throne. It had analysed the factors that traditionally brought about the collapse of sporting dynasties. Such declines could, it concluded, inevitably be traced back to a rules upheaval, a person leaving the organisation, or even a factor as subtle as a change in the composition of the tyres – something it learned through Michael Schumacher’s struggles in his ill-fated racing comeback.

“Formula 1 is physics, not mystics,” stresses Wolff. “We can almost trace back to the day we made a ▶

BELOW Will the discomfort Lewis Hamilton endured last season translate into a painful 2023 campaign for rivals?

Mercedes-AMG F1 Team

> *“Formula 1 is physics, not mystics. We can almost trace back to the day we made a decision that sent us on the wrong development path”*

decision that sent us on the wrong development path.

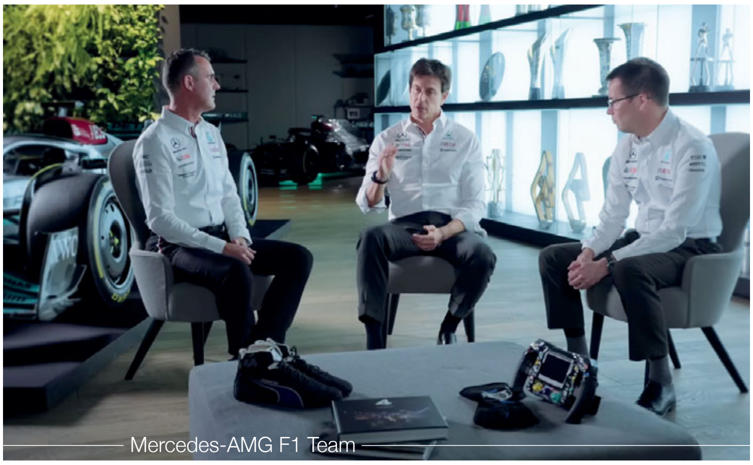
“I remember us discussing back in October [2021] how exciting it was to find performance through the floor. The real trick was how low can you get the car? That sent us off on the wrong trajectory.”

Why porpoising persisted

Although the problem of porpoising caught many by surprise as teams adapted to the return of ground effect, most forecast that the issue would be eradicated within a few races. Yet it persisted – growing progressively worse as teams fought for on-track supremacy – until the governing body intervened with the introduction of a metric to measure the oscillations and therefore lead to a punishment.

“The reality is that the really good aero stuff is down at the bleeding edge, running the cars stiff and at their lowest ride height,” explained Race Tech’s Expert Witness, an F1 insider, at the time. “So if that’s where the good stuff is, it’s like bears eating honey. The bees are going to sting you, but it’s just so good, you can’t keep away.

“As a team, you could just run the car higher, but you won’t, because it’s slower. So you have to either be in that uncomfortable zone or figure out a way – and it could be aerodynamic or it could be vehicle dynamics.”▶


Mercedes-AMG F1 Team

ABOVE Hywel Thomas, Toto Wolff and Mike Elliott have opened up about a painful season

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ABOVE Circuits like Baku, where George Russell complained of being "shaken to pieces", brought the porpoising problem to a head

In truth, Mercedes feared it might have issues even before the car had turned a wheel in anger. Those suspicions were confirmed then it turned up for its pre-season filming day at Silverstone. The circuit was wet, the wind was gale force. Those involved quickly realised the winds of change were about to blow through F1.

"We'd heard rumours that teams were struggling, that they had turned up for filming days and not been able to run," recalls Technical Director Mike Elliott. "So when we did our filming day and found the car bouncing, we knew we had a problem.

"The aerodynamics of these cars are such that they want to run really low to the ground. What we were finding in the tunnel was huge gains with the car operating in that way. When you look back at the season in hindsight, we pushed too far in that direction – and we've learnt a lot as a result!

"Any normal season up until now, you've been able to look at what comes out of the power unit, what comes out of the wind tunnel and also out of our simulation and know where you're going to be with the car," he explains. "Normally we start the season with a pretty good understanding of where we are relative to the previous car. Obviously you don't know what the competitors are going to do, but you know where you're going to be and it was the first season I could remember in a long time where we started with a problem we didn't predict."

Perfect storm

In many respects, this was the perfect storm. At the same time as the aero engineers found themselves in unfamiliar territory, their powertrain counterparts were also coming to terms with a seismic shift in the landscape. They were arriving at the end of an exhaustive push to extract the most from the Power Unit, in the knowledge that the hardware was about to be frozen for the next three years. So too, they faced the uncertainty of the switch to a 10% ethanol biocomponent in the fuel – almost double that which the world championship had used in 2021. They knew that entailed taking a hit themselves, but how much would it hinder rivals?

"When we hit the track, I think there was a bit of disappointment," accepts Hywel Thomas, Managing Director, Mercedes AMG High Performance Powertrains. "There were some things that we could certainly do with putting right, and we knew that we couldn't do it through hardware, which had been our way of developing things for the past however many years. So we had to go back and reconsider: how were we going to develop ourselves out of that position in this new world?"

The first thing that required addressing was the pressing need to deliver better driveability for the already beleaguered drivers. To compound matters, the porpoising was so extreme that it was actually breaking the engines.

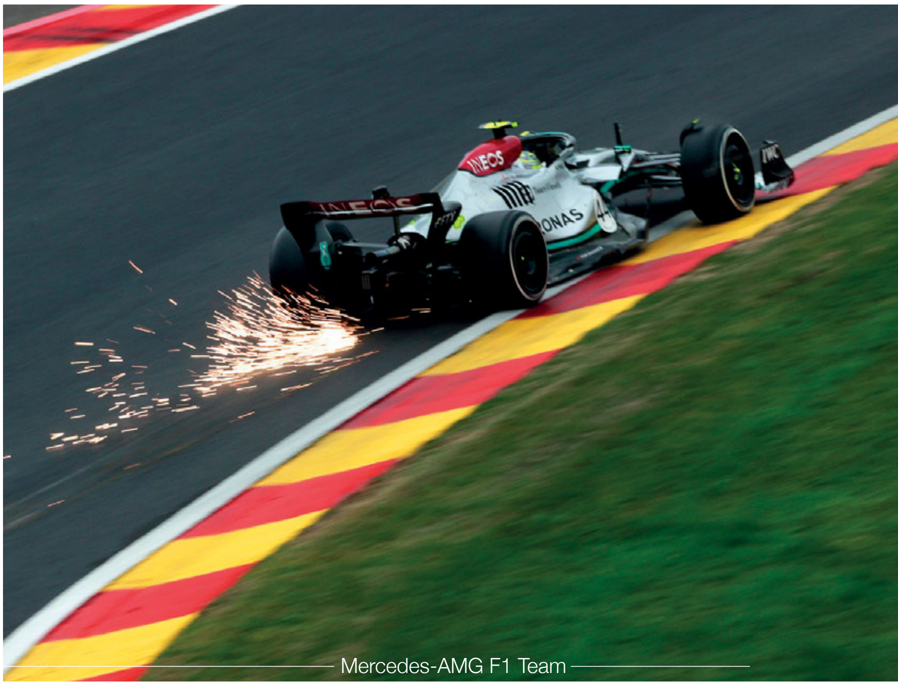
"It was becoming clear that the engines were taking a hell of a pounding," explains Thomas. "When you saw the bottom of the race engines when they got back to Brixworth, it was quite a surprise to see how hard they were being hit by the ground. When you saw Lewis and George looking uncomfortable getting out of the cars, the PUs were doing much the same!"

> ***"The engines were taking a hell of a pounding"***

Although the bouncing captured the headlines, in some ways it masked the fact that the W13 was actually beset by myriad other problems too. "Basically every stone you turned over had a problem underneath," reveals Wolff.

"Bouncing was the dominant problem and the most ▶

BELOW The 'Zero-sidepod' package wasn't as big a performance factor as some had predicted



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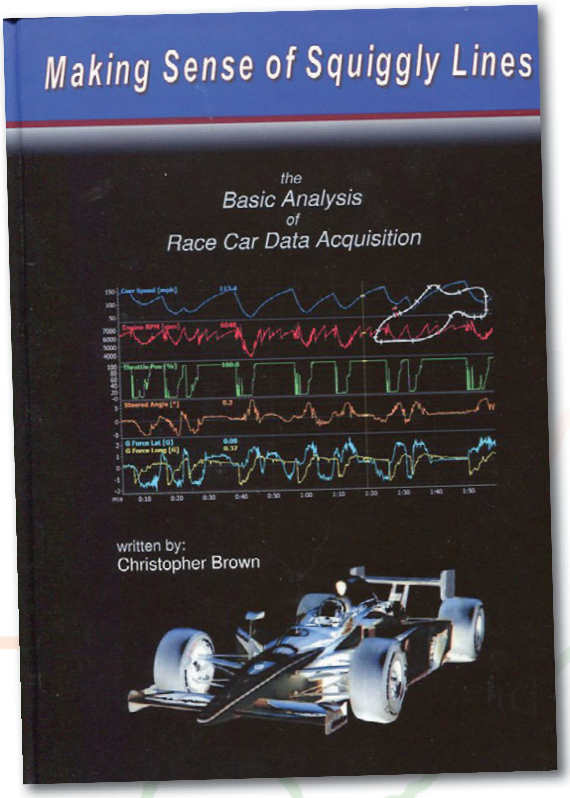

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visible, but the aero characteristics are difficult… the stiffness of the car to the point where the suspension is pretty useless, stiffer than the tyres," a disgruntled Lewis Hamilton reported at the time.

Worse still, the W13's drag issues at high-speed circuits were also being exposed.

"Drag is a huge problem for us," confessed Hamilton "When we get to a certain speed that's when other people are pulling away. It's when you brake and the front dips and the rear comes up and the aero transfers during that period and when you get on the power."

There were odd occasions early in 2022, such as at Barcelona, where it appeared that progress was being made. But exposure to bumpy surfaces, notably in Monaco and Baku, once more betrayed the car's problems.

Such is the complexity of modern Formula 1, that there is no quick fix when a team has committed to the wrong development route. Much of the squad's early activity involved trying to model things in the wind tunnel, attempting to understand them and then bring experiments to the track to confirm that knowledge. It was mystified that the team's sophisticated simulation tools hadn't predicted the problem as it chased aero performance.

ABOVE If it's any consolation, Lewis, the engine is feeling the same!

The step forward it made for Barcelona came at a high cost.

"We gave up a big chunk of raw wind tunnel performance in an attempt to massively reduce the bouncing," reveals Elliott. "We now had a car that we could run more of less where we wanted to run it in terms of ride height but we had given up a massive chunk of performance to get there."

Wolff suggests that the races from Barcelona to Budapest were: "Trial and error, trying to correlate what we didn't see in the data with what was happening on track."

It was a measure of the team's woe that its talented drivers could finish no higher than third position in the first 11 races. Conversely, that record serves to highlight just how well the squad fought back in the second half of the season. And it is a demonstration of Mercedes' confidence that those issues are now resolved that, for the first time, it has gone public about its confusion when porpoising first struck.

Fightback

So what were the keys to that recovery?

It's about sticking to your core values, insists Wolff: "All the pillars were still in place. You win a ▶

> *"You haven't become completely incompetent in the space of four months!"*

BELOW The pre-season filming day confirmed suspicions that porpoising would be a problem

Steve Etherington/LAT Images/Mercedes-AMG F1 Team

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"This can't be happening!"

Toto Wolff reflects on the psychological impact of dealing with defeat

WHEN Mercedes won both the Sprint and the main Grand Prix in Brazil last season, the team celebrated as if it had just won a World Championship.

It was a venting of frustration, an outpouring of relief, a product of the passion felt back in Brackley and Brixworth. But was it also a dangerous sign?

"It was interesting to look at ourselves in Brazil," admits Team Principal and CEO Toto Wolff, recalling the jubilation. "It was an emotion I hadn't seen coming. The important thing is that we maintain that scepticism. We have to be honest with ourselves that while we made good progress, displayed a good attitude, we knew we would only see the benefit from that in the coming year. The learning was, for me, more important than winning a race. It was good proof for us that there was inherent pace in the car if the DNA of the circuit fitted our car."

Wolff paints an interesting picture of the philosophy of winning – and losing.

"It comes in quite an interesting pattern," he muses of the team's fall from grace last season. "In the beginning, you are in disbelief. This can't possibly be happening. Then comes the phase where you think, 'Okay, this is just a blip. We got things really wrong. This is an organisation that has been successful in the past.'

"But then the real risk is that you change your expectations and say, 'Well, we've lost that one already,' or you get used to a podium and you say, 'Well, that wasn't so bad, we finished second and third.' In a way, losing doesn't become as painful as it was before and that's a real risk.

"Suddenly you end up on the podium and you think it's a success. And it's not. You have to remind yourself that this result last year would have been seen as a defeat.

"It's how the mind works. It's almost protecting ourselves from feeling our own mediocrity, I guess…" RT

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ABOVE Merc's euphoria in Brazil was an outpouring of relief

championship in December but when you hit the ground in March you are much too slow. You are not taking a 'stupid pill' that means within four months you are becoming totally incompetent!"

That self-belief was evident in the way that everyone maintained their composure in the midst of the storm. "What I saw in both factories is that when things weren't going well, nobody turned on each other ; nobody was pointing fingers," stresses Thomas.

"We trusted the process of how to develop the car. It was a case of, 'Okay, we've learnt something new so we need to adjust that process. We need to do things a bit differently but, inherently, it's the right way of doing things.'"

Beyond getting the porpoising under control, one of the important factors in the fightback was an improved understanding of where the relationship between drag and PU performance lay.

"What became clearer and clearer was the link between the power unit and the chassis: you can't develop them separately," observes Thomas. "If you want to get that performance from the PU, you have to match them even more beautifully to the chassis. That, especially in the second half of the season, was where some of the gains were coming from."

Although engine and aero departments sometimes compete for real estate in a car's design phase, you can hear the sympathy for his chassis colleagues in Thomas's voice when he says, "PU-wise, we were trying to add performance through small gains at pretty much every event, but without compromising the reliability. We're fortunate in that we can see those numbers on the dyno. It's comforting to see that, watch that working and know we can say, 'Okay, we're taking that to the circuit.'"

If the first part of the campaign had thrown up a few false dawns, there was a far more predictable pattern to the team's performance as the year progressed. It entered the summer break on a high, buoyed by George Russell's pole position in Budapest.

By that point, it knew that PU and car performance fell into the sweet spot with low-speed high performance. Spa and Monza, where the car would be too draggy, were always going to be painful. By Austin, however, while the car wasn't exactly a Red Bull-eater, the team had established sufficient confidence that it knew which direction to pursue for the future.

That spectacular Brazil double win (see sidebar) might have been the high point of the season, but by then the performance in Mexico had already confirmed that Mercedes had overhauled Ferrari. The latter maintains, quite rightly, that it had switched its attention to its next car by then, while its rival still appeared to be developing the W13 aggressively. But did it *really* believe that Mercedes hadn't also long had 2023 in its sights?

Mercedes hopes that the depths of its 2022 misery might come with a silver lining: finishing third in the Constructors' Championship earned it a bigger share of wind tunnel/CFD resources for the coming campaign than a ninth consecutive title would have done. At the same time, Red Bull's penalty for breaching the financial rules will further reduce its allocation.

But that extra wind tunnel time that Mercedes enjoys will have to be well utilised, revealing the true extent of its understanding of where the design of the W14's predecessor went awry.

Those who revelled in Merc's pain last season might themselves experience discomfort this month as the new cars hit the racetrack.

"We will rise again," warns Wolff. "The days we lose are the days our competitors will regret the most, because these are the days we learn…" RT

BELOW The team's sophisticated tools had not predicted that bouncing would be a problem as the cars returned to ground effect

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> *"The days we lose are the days our competitors will regret the most"*

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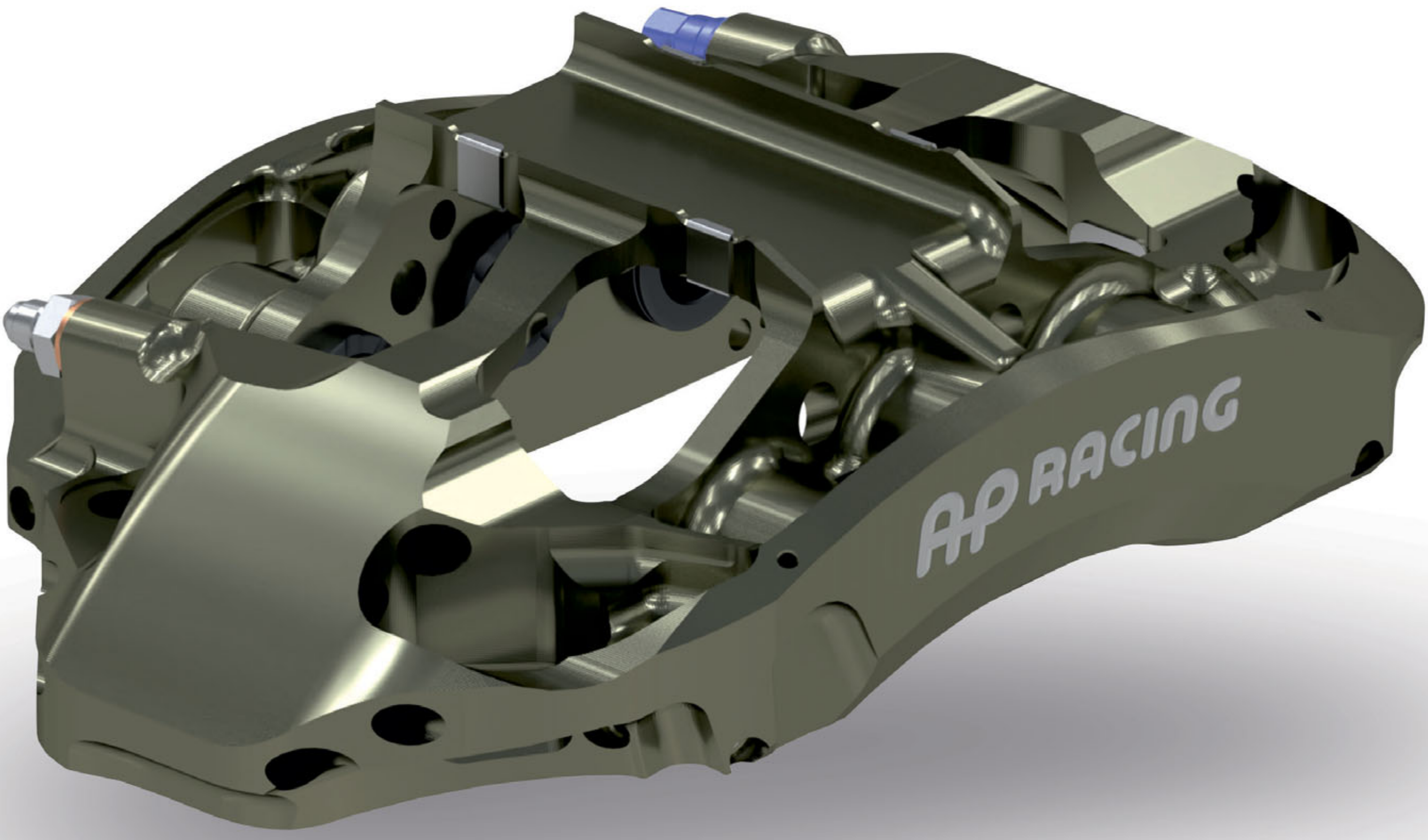


ROLEX 24 USHERS IN SPORTSCAR RACING'S *'NEW NORMAL'*

AP Racing's engineers talk **Chris Pickering** through the challenges of developing brakes for the new GTP (LMDh) era

OF all the changes that have helped to carve the new GTP/LMDh category out of what was previously DPi, one stands head and shoulders above the rest. Sure, there are revisions right across the car, but the big conceptual difference is the spec hybrid system mounted at the rear.

It's not just the integration of the hybrid system and its associated battery and electronics that complicates things. The effects of this change can be felt throughout the car. Notably, the braking system no longer operates in isolation – a substantial amount of the braking torque on the rear axle now comes from the motor generator unit, which can regenerate at up to 200 kW (four times the power it can deploy under acceleration). At other times, however, the discs and pads may have to handle the full braking torque on their own, with the front-to-rear bias shifting correspondingly.

To find out more about these challenges we're speaking to AP Racing, which is supplying two of the four LMDh-approved chassis manufacturers. (Although the company won't disclose which ones, now that the cars have been stripped bare in the paddock we can confirm it is Porsche and Acura.)

So, what characterises LMDh, from a braking perspective? "Compared to, say, LMP1, you have a heavier car with slightly slower cornering speeds, with some of the lap time made up with higher speeds down the straights," explains Jason Carpenter, trackside support engineer for AP Racing. "This means you've got longer stopping distances and more energy to handle in the braking zones, so it's about how you manage that energy – both with the

> *"You've got longer stopping distances and more energy to handle in the braking zones"*

hybrid system and the friction brakes."

Different chassis manufacturers may have different approaches as to how much regenerative braking they anticipate using on parts of each circuit. The regenerative braking on the rear being active or not (in the most extreme case) can see a large temperature swing, and clearly has a significant influence on the approach to the risk and airflow required regarding the brake sizing at the rear, but it's also actually the cooling around the front wheels that has provided one of the biggest discussion points, notes Carpenter.

"The front brakes already have to work harder. And the longer distances and heavier cars that we've got now means that the cooling there has to be optimised carefully [with regards the venting in the discs and calipers]. That's a challenge in itself, especially given the cost control element," comments Carpenter. "On the rear, the challenge is the temperature difference between the regen being used and not being used. The difference could be up to a 300 deg C swing in the most extreme scenarios, according to our simulations."

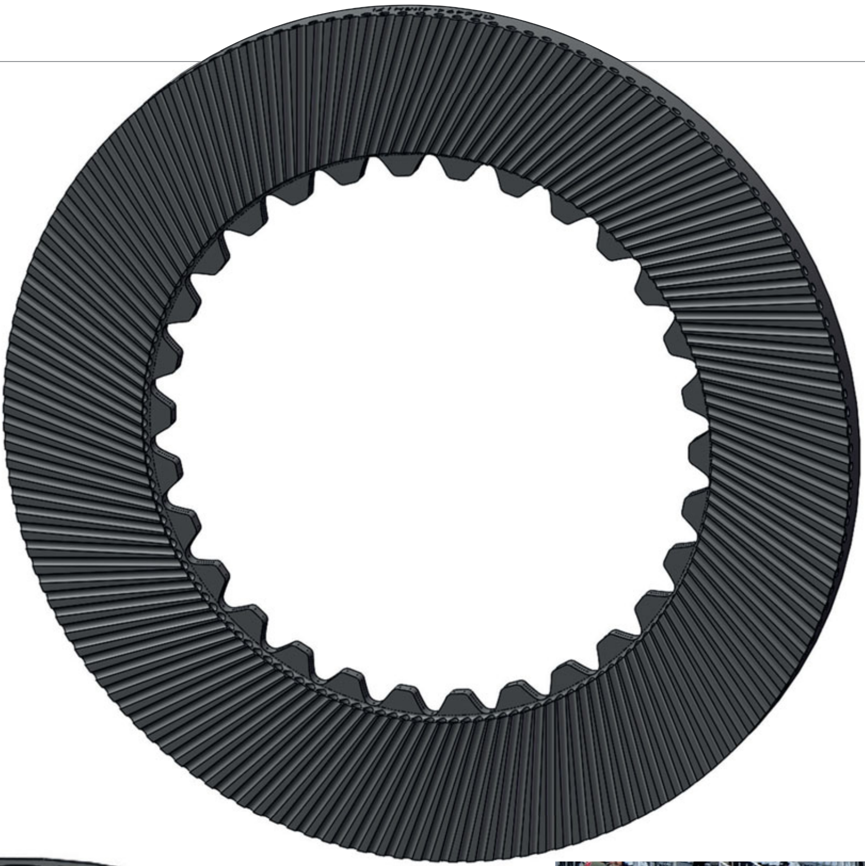
As such, the rear brakes have to be designed with adequate cooling for a worst-case scenario. It's thought that the car could continue to run at a competitive pace for as many as three additional laps after a failure in the regenerative braking system. A broad range of operating temperatures gives the braking system its best possible chance of maintaining performance until the car can come into the pits – with unscheduled downtime potentially a major issue in endurance racing.

Ultimate regen strategy

It also helps the teams to explore a range of different operating strategies with a fully operational regen system, Carpenter points out: "It's going to be interesting to see how everyone achieves what they feel is the ultimate regen strategy. Over time I suspect that'll tend to converge as everyone establishes the quickest way to cover the lap, but it's not immediately clear. You might have a certain percentage on each braking zone, for instance, or you might tend to focus on specific parts of the lap for harvesting that energy."

While the brakes are in their ideal temperature range, the wear should be roughly equal between the pad and the disc. Going above or below that temperature range can affect the two halves of the system differently. The AP engineers aren't keen to go into details here, but the bottom line, we're told, is that running the brakes below their ideal operating range is the lesser of two evils. ▶

LEFT & BELOW AP Racing has developed a new caliper design for LMDh (rear, left; front, below), using its patented Radi-CAL technology

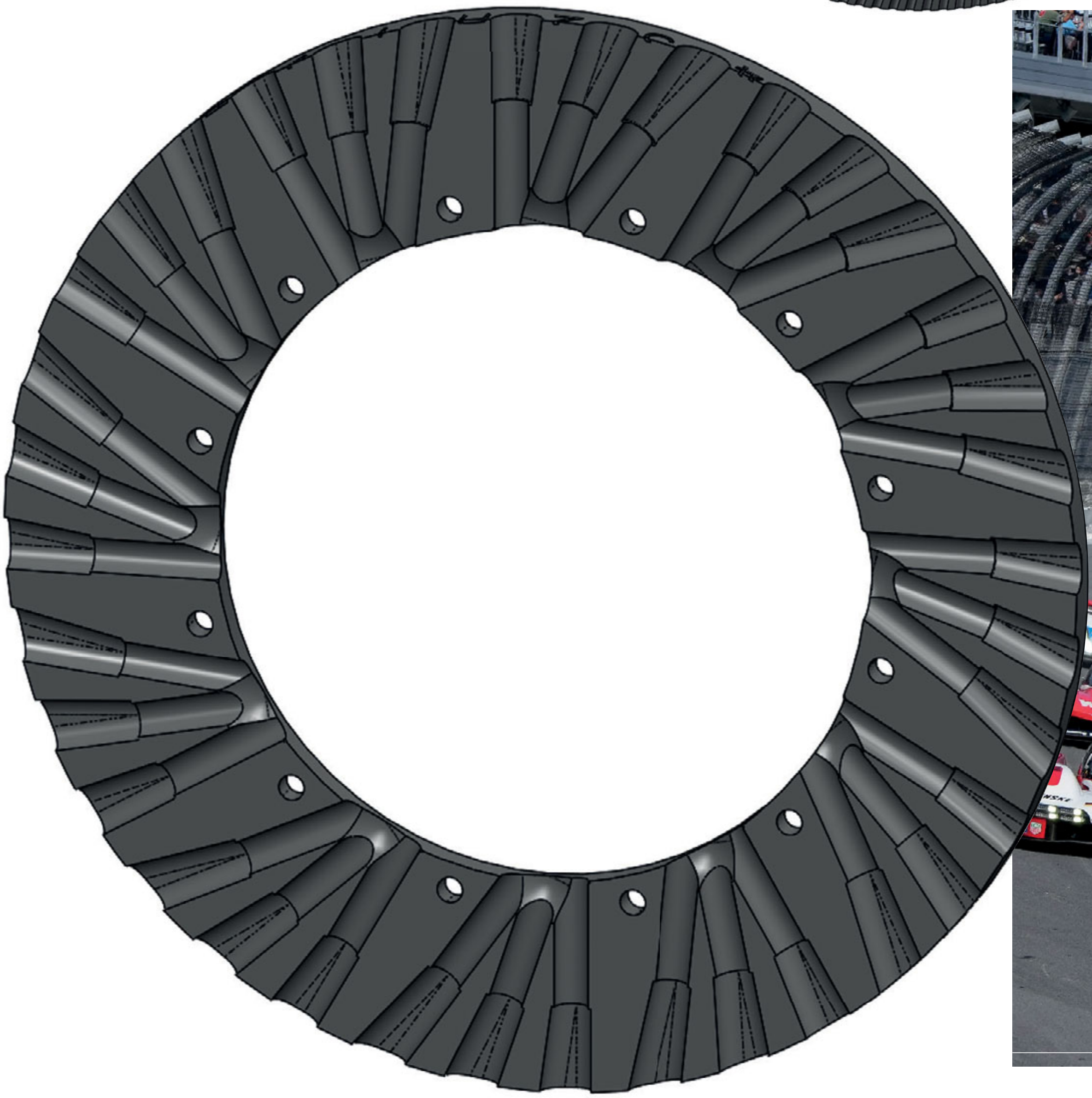


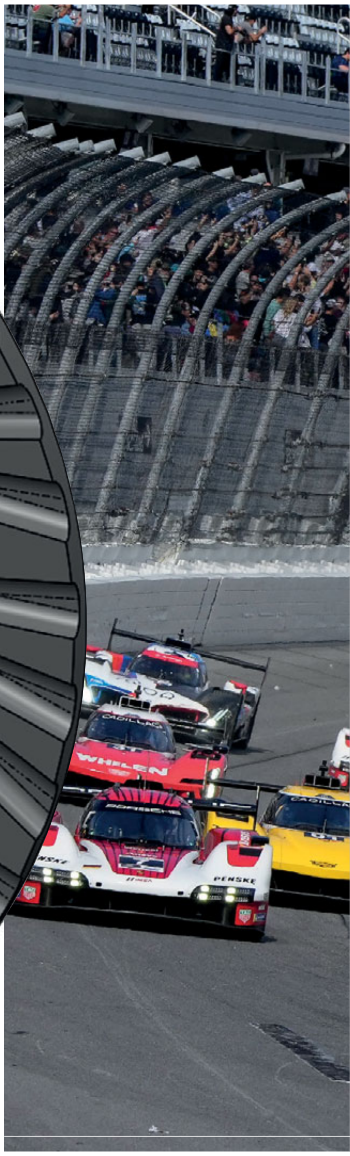
Comfort zone

The carbon-carbon material used in the LMDh brakes is designed to work from around 300 deg C. It's described as being "comfortable" up to somewhere in the region of 650 to 700 deg C (depending on the duration) and capable of withstanding brief peaks in excess of 900 deg C. It's said to use the same well-proven base material that's found in LMH, LMP2 and the previous generation of LMP1 brakes.

"Our material is known to be particularly adaptable to different temperatures, which is why it's so prevalent in endurance racing," notes Richard Gregory, Head of Commercial at AP Racing. "In a 24-hour race you've got traffic and caution laps to contend with; you've got gentleman drivers and top-end pros; and you can also have ambient temperatures that are approaching 30 deg C in the middle of the day but then down into single figures at night at the same event, without much scope to change the ducting.

"So you might be looking at a low of 300 deg C as





LEFT Cooling has had to be optimised carefully. There is a notable difference in the cooling requirements of the LMDh-style disc (above left) compared to an LMP2-style design (below left)

the brake-on temperature at the start of the braking zone on a 'cool' lap, compared to a peak temperature of more than 800 deg C at the end of the braking phase on a 'warm' lap. If you're consistently running into the thousands it will move into an oxidation window where you won't get the power or the durability that you need for an endurance race."

This goes back to the design of the brake hardware and the ducting on the car itself. One team might elect to take a more conservative strategy, with the brakes coming on at 300 deg C and peaking at 650 deg C in normal running, where another may decide to push that range up to 350 deg C and 700 deg C respectively, at the cost of a reduced safety margin.

Cost control

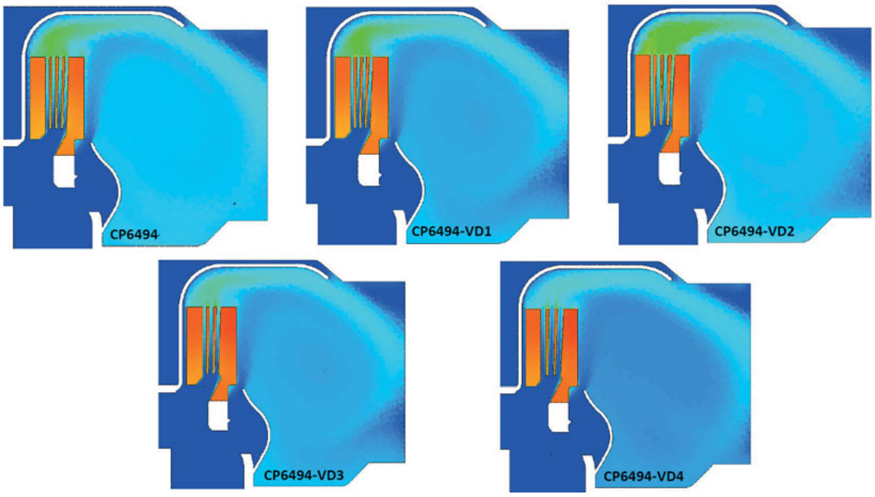
AP Racing has a longstanding relationship with US company HITCO Carbon Composites, which pioneered the use of carbon-carbon brakes in Formula 1 in the 1980s (its other notable achievements including contributing to wins at both Le Mans and the Indy 500, not to mention supplying materials for NASA's Apollo programme). The two organisations collaborated on the manufacturing and development of the materials, which in the case of the discs and pads are AP Racing's H17i and H18 compounds respectively.

The core concept of LMDh is to provide close racing with a hybrid platform at a manageable cost. That cost control philosophy can be seen in things like the spec hybrid system and the four homologated chassis, but it also extends to details such as the brake ▶

> *"The braking system no longer operates in isolation – a substantial amount of the braking torque on the rear axle now comes from the motor generator unit"*

BELOW Daytona marked the dawn of a new era, with Acura's AP Racing-supplied ARX-06 winning the first race of IMSA's flagship GTP category

Richard Dole/LAT/IMSA



ABOVE This indicative visualisation of cooling effects from different venting patterns was part of a range of work conducted during AP Racing's LMDh/GTP development phase

design and the ducting. In Formula 1, for example, the teams may have three or four different options at any given circuit to fine-tune the temperature range, but the aim in LMDh is to minimise the number of parts that need to be purchased for each car.

"Throughout this project, the cost element has been fairly prominent in our minds," comments Gregory. "A lot of that is about making things simpler. In a Formula 1 approach you might have intricate bespoke parts made from titanium, which perhaps saves one or two grams. Here, the focus is on making it simpler and more manufacturable while still giving a good level of performance – the calipers, for instance, don't have the really complex organic shape that can take days to machine."

There's nothing especially radical in the design of the LMDh brakes, but as Gregory points out, reliability and durability are generally the driving factors in endurance racing: "It's not unusual for the front-running teams in LMH to buy, say, six or 10 sets of parts ahead of a big race, and they will sacrifice a complete set from that batch to put it through a full 24-hour endurance test. That way, when they start the race, they've already done their own quality control with parts from the same batch. And that's not just brakes, they'll do it with all sorts of things."

AP Racing has developed a new caliper design for LMDh, which uses the company's patented Radi-CAL technology. This is essentially a design philosophy, based around FEA analysis of the dynamic loads on the calipers rather than a traditional static loading case.

"These are asymmetric calipers with various ▶

Porsche AG

BELOW AP Racing had designs underway for teams to test before the rules were even finalised. Porsche's 963 is seen here with its discs aglow early in the testing stage

Giorgio Piola

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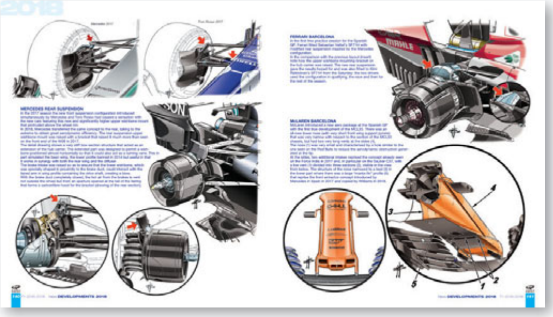

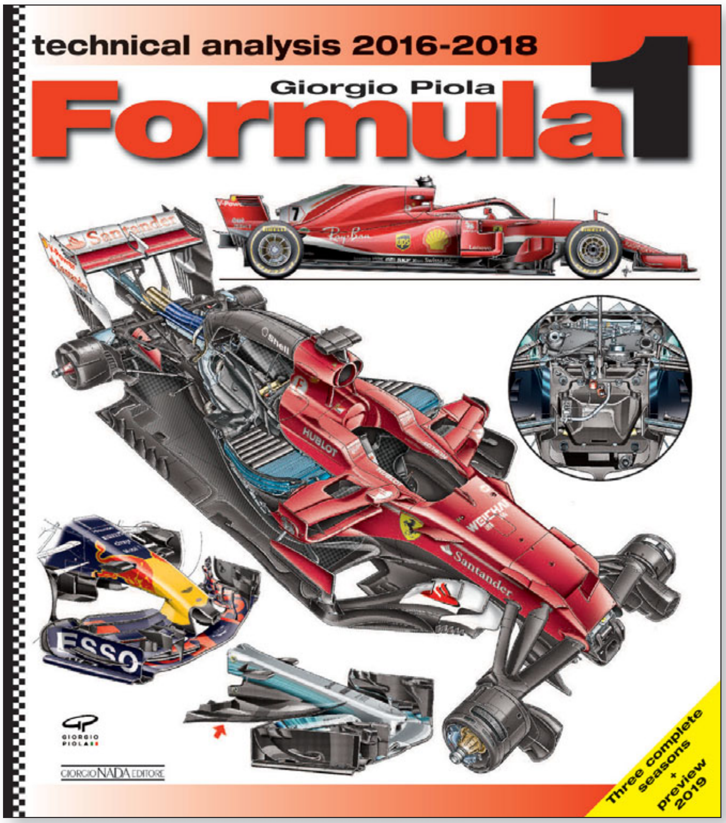
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patent-protected features to optimise their weight and stiffness," comments Gregory. "Although they're new for LMDh, we've commonised as much as possible between the manufacturers to increase the production volumes and keep costs down."

The calipers are understood to be slightly larger than those used elsewhere in endurance racing. A larger than average stack width of 100 mm allows more material thickness to be used, increasing the lifespan of the discs and pads. Similarly, the hydraulic components have been sized to keep the pedal effort manageable for gentleman drivers, with the bore size on the rear calipers tweaked to ensure adequate performance in the event of a regen failure.

As an example, AP Racing's LMP2 brakes use a 32 mm thick disc, which can operate down to 25 mm thickness. That's now easily enough to do a typical Le Mans 24 Hours race, although some teams still choose to change the brakes halfway through as a precautionary measure or if they feel it will give better operating characteristics. The teams will see maybe 5 mm of wear over the course of a 24-hour race, and the same on each pad. As such, the 100 mm stack width on the LMDh pads allows for a substantial amount of wear – enough to potentially cover several events on the same set.

"It was quite a while before the specific regulations for the brake were finalised, so we had designs underway for teams to test before we knew exactly what the finished specifications would be," notes Gregory. "At some points we weren't sure if there would be any limits on the number of holes or any material restrictions, so we were going on the guidance of what the chassis manufacturers were coming to us and asking for."

Tech transfer

Aside from the financial implications of manufacturing and consuming parts, there's also a growing trend within brake development to look at their impact on the vehicle's sustainability. For instance, would a slightly more complex machining operation on the disc increase the effectiveness of the cooling and therefore reduce the wear rate and increase the stack's lifespan? Similarly,

> *"Recycling, including secondary and tertiary uses for the carbon, is something that's under consideration"*

pad areas can have an impact on wear rates.

With more and more cars moving towards zero tailpipe emissions, brake particulate emissions are starting to become a major talking point in the road car world. Carpenter says it's something that the engineers are aware of in the racing world too.

"You get various benefits if you can rely more heavily on the regenerative braking, and obviously one of those is that you'll use less material and so your brake particulate emissions will be lower," comments Carpenter. "That's where it comes back to the importance of a broad temperature range. We hear about Formula 1 discs 'going to sleep' sometimes if they cool down too much, so you need to make sure the materials will work across that full range."

This is just part of the equation, he explains: "If you're running extra slots in the pads, that might make the material engagement a bit more aggressive. In terms of the material itself, you can look at the lay-ups that are used. Depending on how many fibres you have in that three-dimensional axis, you can vary some of the structural aspect of the actual materials themselves to generate less aggressive wear. But there are trade-offs to be aware of with that."

Carbon, of course, remains a relatively energy intensive material to produce, although at this sort of performance level there isn't really any other material that could cope with the thermal loads involved once the parts are on the car. During the manufacturing phase, it would be possible to switch to renewable energy sources for the furnaces. Recycling, including secondary and tertiary uses for the carbon, is also something that's under consideration.

"As you recycle it the material becomes progressively less useful, but there are still things that you can do with it the second or third time around," notes Gregory.

Interestingly, the electric vehicle revolution on the road hasn't impacted the market for friction brakes in quite the way you might expect. Although these vehicles are capable of harvesting significant amounts of energy from regenerative braking alone, they are, fundamentally, big, heavy vehicles that often have far greater straight-line performance than their combustion-engined predecessors. Tesla, for instance, claims a 0-60 mph time of 3.1 seconds for its Model 3 performance – that's well into supercar territory for a family saloon that's priced to compete against the likes of the BMW 3-Series. Consequently, there is still a strong demand for high performance friction brakes.

Emerging EV demands

"Our motorsport mentality is actually very useful for tackling this emerging market of electric production cars," observes Gregory. "We're already used to producing lightweight braking systems capable of dissipating a lot of energy. That's something that we can apply to increasingly mainstream road cars these days.

"The cars themselves may be quite heavy, but that makes it more attractive to the manufacturers if you can save a couple of kilos off each corner with the braking system. Another aspect that's interesting is drag reduction, which is something we looked at a lot in NASCAR when there was open development on the brakes there – minimising the drag on high-speed ovals, but also ensuring that they still had brakes when they came into the pits. That's driving technology transfer in areas where we didn't see it previously. But there are areas where we're having to learn new things like noise."

The AP Racing engineers might be on more familiar territory back on the racetrack, but there's no doubt that the growing use of hybrid technology is posing new challenges. And the role of the friction brakes is only likely to become more complex as regenerative braking capabilities and the reliance on electrified drivetrains increases.

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LEFT With cost control a crucial part of the LMDh gameplan, issues like lifespan and ease of manufacture have defined the design of the brakes for the new GTP prototypes

A CORVETTE FOR THE MASSES?

Chevrolet's customer racing GT3.R breaks new ground for Corvette. By **Mark Skewis**

CHEVROLET'S first GT3 car, the new Corvette Z06 GT3.R, made its public debut at Daytona International Speedway ahead of the Rolex 24.

Design and development of the mid-engine Z06 GT3.R is a collaboration between GM's Competition Motorsports Engineering division and Pratt Miller Engineering.

"The Corvette Z06 GT3.R breaks new ground for Chevrolet and the Corvette Racing program," says Mark Stielow, director, GM Motorsports Engineering Competition. "This customer-focused racecar leverages learnings from throughout Corvette Racing's lengthy and successful history, plus the expertise of our Corvette production design, engineering and powertrain teams."

Based on the highly acclaimed mid-engine Chevrolet Corvette Z06 supercar, the new race car takes the level of technology transfer between racing and production to a new level with more shared components and features than ever before.

"Corvette Racing has been an important influence on the design of Corvette production cars for 25 years," says Tadge Juechter, executive chief engineer, Corvette. "Corvette production and racing teams worked together closely in development to maximize the benefits of a mid-engine design, sharing lessons learned that set both programs up for all-out performance on the track."

The Z06 GT3.R begins its life as an aluminium

ABOVE The 2024 Chevrolet Corvette Z06 GT3.R will target the customer market

chassis frame from Chevrolet's Bowling Green Assembly plant in Kentucky. At Pratt Miller a purpose-built steel roll cage is welded onto a base plate, which is secured to the chassis. The car has double-wishbone suspension front and rear.

Motorsports engineers worked with the GM Design Studio to develop an aero package specific to the Z06 GT3.R to optimize levels of downforce, stability, drag reduction and cooling. The goal was to design a GT3-spec Corvette that is suitable across different tyre specifications, balance-of-performance settings and other customer preferences while not sacrificing performance or drivability on a variety of tracks and racing surfaces.

> *"The powerplant shares more than 70 percent of its parts with the production Z06 engine"*

The fruits of that labour are already encouraging, with works Corvette driver Jordan Taylor pointing out that the existing car was designed for one class and tyre but then adapted to a different class. The new car, by contrast, is designed from the ground up to work on a variety of tyres used by GT3-based series around the world.

"Right from the first three laps, you could already feel that the car suits the tyre better. It works way better. It feels like a race car again," he says.

"I think it's a huge step forward from the GTD perspective. At one of our tests, we had both cars [new and old] at the same track at the same time, and going from car to car was night-and-day difference of how the cars handled and work the tyre."

The car features a new carbon fibre splitter and diffuser. Intakes at the front of the Z06 GT3.R draw in air to cool the front brakes. A single, large opening on the hood – a new design philosophy from ▶

the C8.R – extracts air after it moves over the radiator. Side air ducts behind the doors – directly inspired by the Z06 production road car – help to cool the engine, transaxle and rear brakes.

The Corvette Z06 GT3.R will feature a 5.5-litre, flat-plane crankshaft DOHC V8 engine derived from the production Z06. This engine began on-track development in 2019 with the initial testing of the C8.R, ahead of its use in the production Z06.

Valuable lessons

The LT6 engine for the GT3.R originates from the Performance Build Center in Bowling Green, the same line on which all production Corvette Z06 engines are built. The powerplant shares more than 70 percent of its parts with the production Z06 engine, including the crankshaft, connecting rods, cylinder heads, fuel injectors, coils, gaskets and a variety of other sensors.

"Racing continues to play a key role in the development of our production engines," says Russ O'Blenes, director, Performance and Racing Propulsion Team. "There were valuable lessons learned during the C5-R through C7.R programs that aided in the development of our V8 engines for production and racing – many dealing with efficiency, materials and light-weighting. The flow of information from Corvette Racing to production engineering and back has helped us build race and street-car engines that are fast, reliable and efficient."

Chevrolet and Pratt Miller have worked together to incorporate a number of features into the GT3.R, building on safety construction from the C8.R. The Z06 GT3 features a side-impact crash structure between the driver's side door and roll cage. Pioneered in the C7.R, the box features an outer casing of carbon fibre and Kevlar, and is filled with an aluminium honeycomb construction.

The GT3 Corvette's integrated steel roll cage is slightly modified from the current racing Corvette to provide easier ingress and egress.

The reveal of the Z06 GT3.R follows a two-year testing programme. Virtual simulation through Chevrolet's Driver in the Loop simulator began in early 2021.

The first on-track test of the Z06 GT3.R took place in September 2022 – which means the Z06 GT3.R will have a full year of on-track development when it gets into the hands of customers in the third quarter of 2023.

"We're all very pleased with the results from the track testing program so far," says Laura Wontrop Klauser, GM sports car racing program manager. "What's even more encouraging is the correlation between simulator sessions and what we're finding in the real-world track testing. It's another level of validation that gives us confidence in the development process."

Where the racecars have for seasons been developed exclusively for Corvette Racing's works drivers, the customer project demands that a broader range of skill levels be considered.

"There have been more discussions during the process about making the car more suitable for

ABOVE A big departure from the usual works programs, the Z06 GT3.R will benefit from a full year of track development by the time it reaches customers

RIGHT Chevrolet expects as many as four Corvette Z06 GT3.Rs to be on IMSA's 2024 WeatherTech Championship grid everybody and not just for Corvette Racing,” acknowledges development driver Tommy Milner. “In terms of ergonomics, parts of the car are designed for different size people than us and things like that.

“As we go further into the process this year with some of the finer details, some of the driver aids like ABS and traction control, we’ll be taking more time than normal to really make sure that is usable in all ranges of conditions.”

The Z06 GT3.R is the latest in a line of championship-winning Corvette race cars that date back to the late 1990s and the introduction of Corvette Racing and the Corvette C5-R. Entering its 25th season, the program has scored 122 race victories around the world, including 113 in IMSA competition.

Those wins have led to 14 Manufacturers’ and Drivers’ championships and 15 Teams’ titles. No team in IMSA history has won more races or championships than Corvette Racing in that span.

> “The new race car takes the level of technology transfer between racing and production to a new level”

The mid-engine C8.R – the predecessor of the Z06 GT3.R – has won 15 times around the world since its on-track debut in 2020. The 2023 season will be its second and last with a dual program in both the WeatherTech Championship and the FIA WEC. The latter will move from the current GTE regulations to the global GT3 platform beginning in 2024.

CORVETTE
03
03
GT3.R

Customer support

Chevrolet and Corvette Racing is establishing a complete customer support program that will be available to teams running the Z06 GT3.R in North America and elsewhere around the world.

An at-track parts truck will be a fixture at North American race events starting in 2024 with expansion to overseas support ramping up in the first two years of the Z06 GT3.R program.

Corvette Racing will carry full spares packages of bodywork and internal components for its customer teams in supported championships. On the technical side, engineers will assist teams with items such as pre-race documentation, including chassis setup and data sharing plus post-event documentation, data analysis, and relative comparisons.

Full engineering, race strategy and other items also are incremental support options for Corvette Z06 GT3.R customer teams.

Customer integration doesn’t stop at the racetrack. Corvette Racing and GM Motorsports engineers will be available for remote engineering and operations support.

“Supporting our customers is an area where we are putting in a lot of time and effort,” says Christie Bagne, GM assistant sports car racing program manager. “With this being our first customer GT3 offering, we have had meetings with many prospective customers to learn from their previous experiences, find what is important to them from a support standpoint and come up with a program that meets their expectations.”

Chevrolet expects to see as many as four Corvette Z06 GT3.Rs on the 2024 WeatherTech Championship grid, split between the GT Daytona Pro (GTD PRO) and GT Daytona (GTD) classes. Two Corvette chassis will be bound for FIA WEC, where the campaign will include the 24 Hours of Le Mans.

Chevrolet Motorsports will also be evaluating opportunities to be represented in SRO Motorsports including SRO America and the Intercontinental GT Challenge.

“This has been an intense but very rewarding process,” Klauser says. “From the time we announced a Corvette GT3 car, I’ve received more inquiries than I can count. It’s a testament to a known product like Corvette, the minds behind design, development and build, and the quarter-century success of Corvette Racing.” RT

FORMULA E CHARGES INTO A NEW ERA

Fast charging is just one of several exciting developments to be explored by Formula E’s new racecar. **Chris Pickering** talks to Alessandra Ciliberti, the FIA’s Formula E technical manager and Gen3 project lead

IT’s easy to underestimate the leap forward that Formula E has taken with the new Gen3 cars. The all-electric race series has been with us for the best part of a decade now. During that time – much to Formula E’s credit – we’ve become normalised to the idea of electric racing.

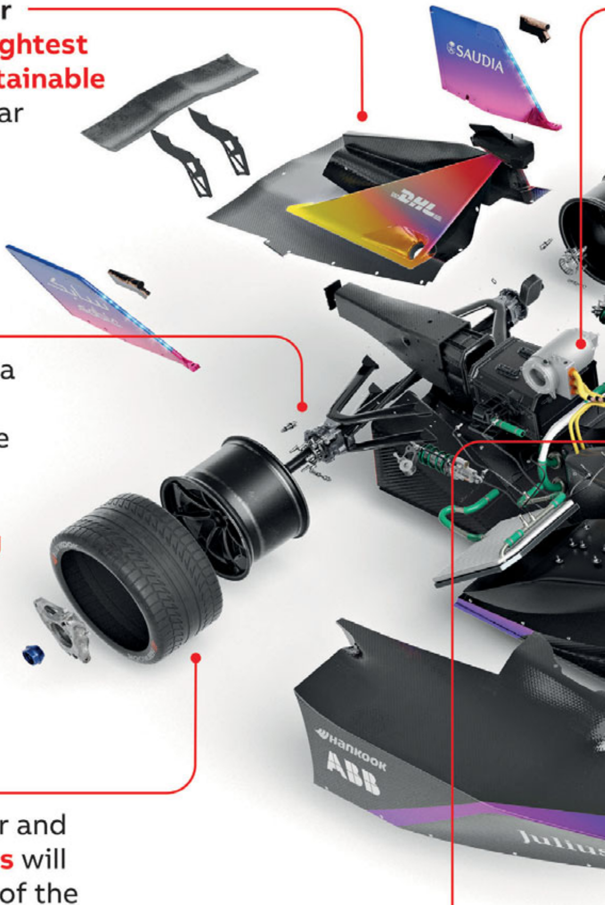
And yet the transition from Gen2 to Gen3 is easily as significant as anything that’s been seen in modern Formula 1. Regenerative power has more than doubled from 250 kW to 600 kW, thanks largely to the introduction of four-wheel energy recovery. Traction still comes from the rear axle alone, but the power here has jumped by an impressive 40 per cent to 350 kW in qualifying trim and during Attack Mode. Top speed is now just over the magic 200 mph mark and the increased regen capability means that the hydraulic brakes at the rear are not used anymore in normal race conditions.

It’s not an incremental update, but truly the start of a whole new era for the series. And despite all the challenges this poses, there were just two mechanical DNFs out of the 22 starters at the season-opening Mexico City ePrix. Despite a number of a teething issues in pre-season testing, it would appear that the Formula E teams have got off to a flying start.

The FIA’s Formula E technical manager and Gen3 project lead Alessandra Ciliberti admits that it was an emotional moment seeing the cars lined up on the grid for the first event. It’s a project she’s been involved with ever since the technical brief started coming together in late 2019. The events since then have been something of a rollercoaster, but Ciliberti describes it as the opportunity of a lifetime.

“I think every single moment has been enriching and challenging at the same time,” she comments. “Gen 3 is a real step change in the technology, and it’s evidence of the incredible progress that has been achieved in this championship.”

Ciliberti was a natural candidate for the role. Following an internship at the Toro Rosso Formula 1 team, she spent three years as a research engineer at BMW working on electric vehicle concepts



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Tires
Natural rubber and **recycled fibres** will make up 26% of the new Gen3 tires from Hankook

Charging
The Gen3 car will be charged by **ABB Formula E race chargers** ahead of the race and between sessions

> *“A top-up of 4 kWh, or 10 per cent of the battery’s total capacity”*

before joining the FIA technical department in 2017. Her previous credits at the Institute include program manager for hydrogen vehicles and various research projects on race and rally safety.

Formula E’s technical development has been her biggest challenge to date. It began with a fundamental rethink on the whole concept of the car.

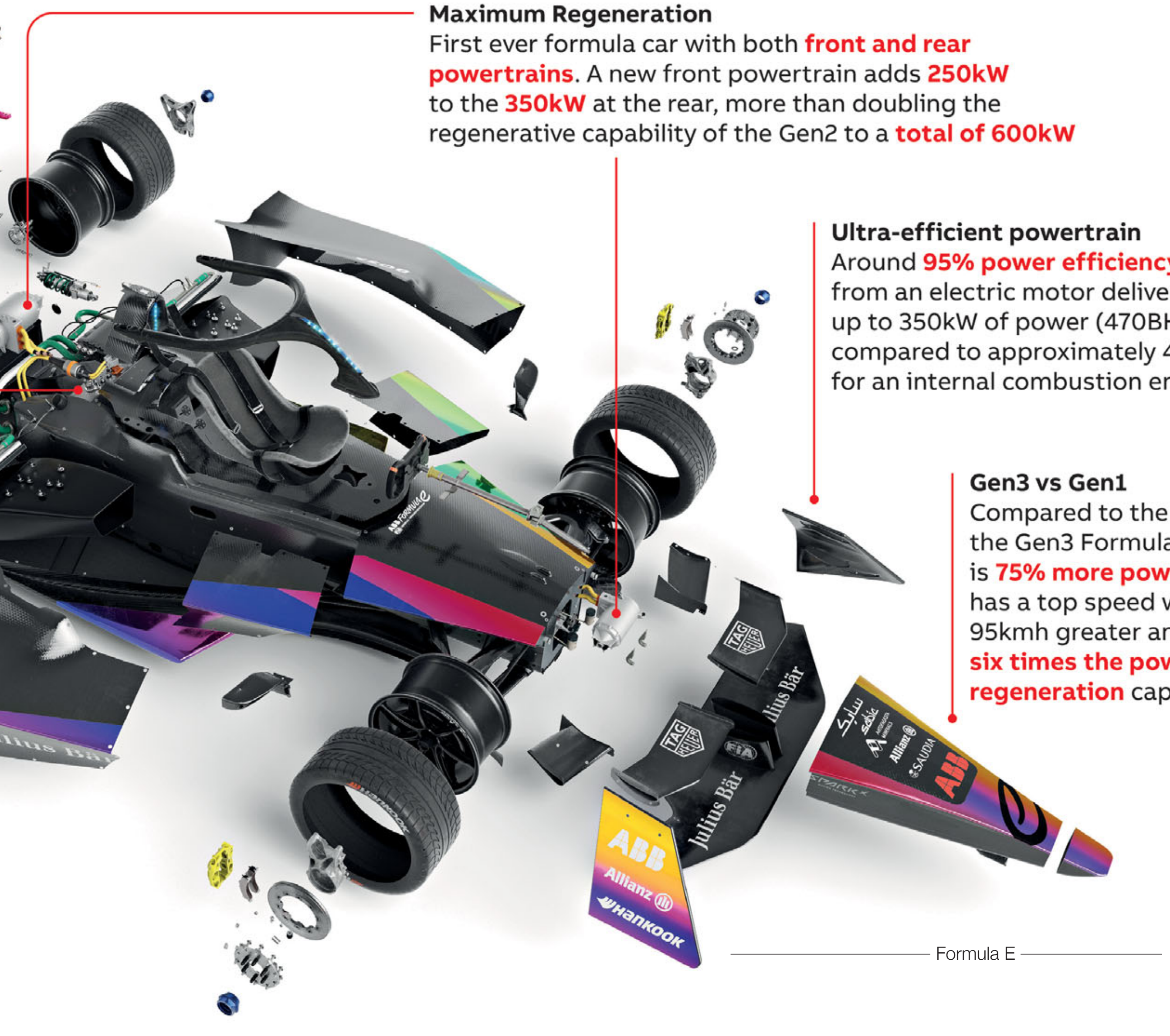
“Essentially what we did with this car was to design it specifically for street racing conditions,” she comments. “Every aspect has been re-thought completely from Gen2 to Gen3. We now have the technology to make the car lighter, so we obviously wanted to do that, but we also wanted to make it smaller and narrower for street courses, while still increasing the performance.”

The minimum weight of the car and driver is 854 kg, which actually makes it lighter than a fully-fuelled Formula 1 car and driver, not to mention a useful 49 kg lighter than the Gen2 car. Most of those savings come from the smaller battery produced by WAE Technologies (recently rebranded to reflect the split from parent company Williams).

Pit stops

The new battery pack is both smaller and lighter than that of the Gen2 car. This was partly enabled by the increased regen capability, with almost 50 per cent of the energy used during the race now expected to come from regenerative braking. The plans for Gen3 include short mid-race pitstops for recharging, which will be introduced later this year.

When it arrives, the planned Attack Charge format will replace Attack Mode, which drivers currently ▶



BELOW An exploded view of the Gen3, which sets new standards for electric racing

Maximum Regeneration
First ever formula car with both **front and rear powertrains**. A new front powertrain adds **250kW** to the **350kW** at the rear, more than doubling the regenerative capability of the Gen2 to a **total of 600kW**

Ultra-efficient powertrain
Around **95% power efficiency** from an electric motor delivering up to 350kW of power (470BHP), compared to approximately 40% for an internal combustion engine

Gen3 vs Gen1
Compared to the Gen1 car, the Gen3 Formula E racer is **75% more powerful**, has a top speed which is 95kmh greater and has **six times the power regeneration** capability

Formula E

unlock by driving off-line in a designated corner. Instead, a mandatory 30-second pitstop during a pre-determined period of the race will unlock two enhanced Attack Mode periods to be deployed later in the race, which will boost power to 350 kW.

"The sporting format is still being discussed," admits Ciliberti. "We're still looking at the strategies on the technical and sporting directions [but] we want to ensure that it's strategic and relevant. It's quite an intense race at 45 minutes, so the charging aspect needs to be relevant to that."

30-second charge

During the pit stops, the battery will recharge at the maximum regen rate of 600 kW. Assuming a full 30-second charge, that works out as a top-up of 4 kWh, or 10 per cent of the battery's total capacity of 40 kWh.

"The pitstop will be mandatory, and as soon as you make it mandatory, it means that you will need to use that extra capacity to stay at a competitive pace," notes Ciliberti.

There were issues with the battery packs during testing – reportedly due to high cell temperatures causing degradation and de-rating – but we're told these have now been solved.

> *"One of the wackier suggestions for Gen4 is an autonomous driving mode for use in the pitlane or while following the safety car"*

With the breadth of new features for competitors to get to grips with before the beginning of the season, it would have been unreasonable to additionally launch fast-charging right from the start. "We need to prioritise making sure that the batteries were okay, and then we can get the cell packs ready for the chargers," Formula E CEO Jamie Reigle commented in a recent interview with Autosport.

Despite these setbacks, Attack Charge is on course to make its debut later in Season Nine, ▶

BELOW For all the technical challenges faced, there were just two mechanical DNFs out of the 22 starters at the Mexico City ePrix

Formula E

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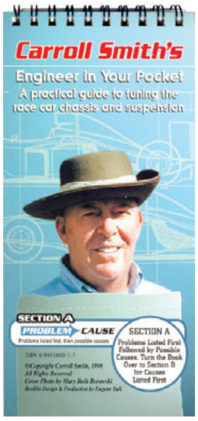
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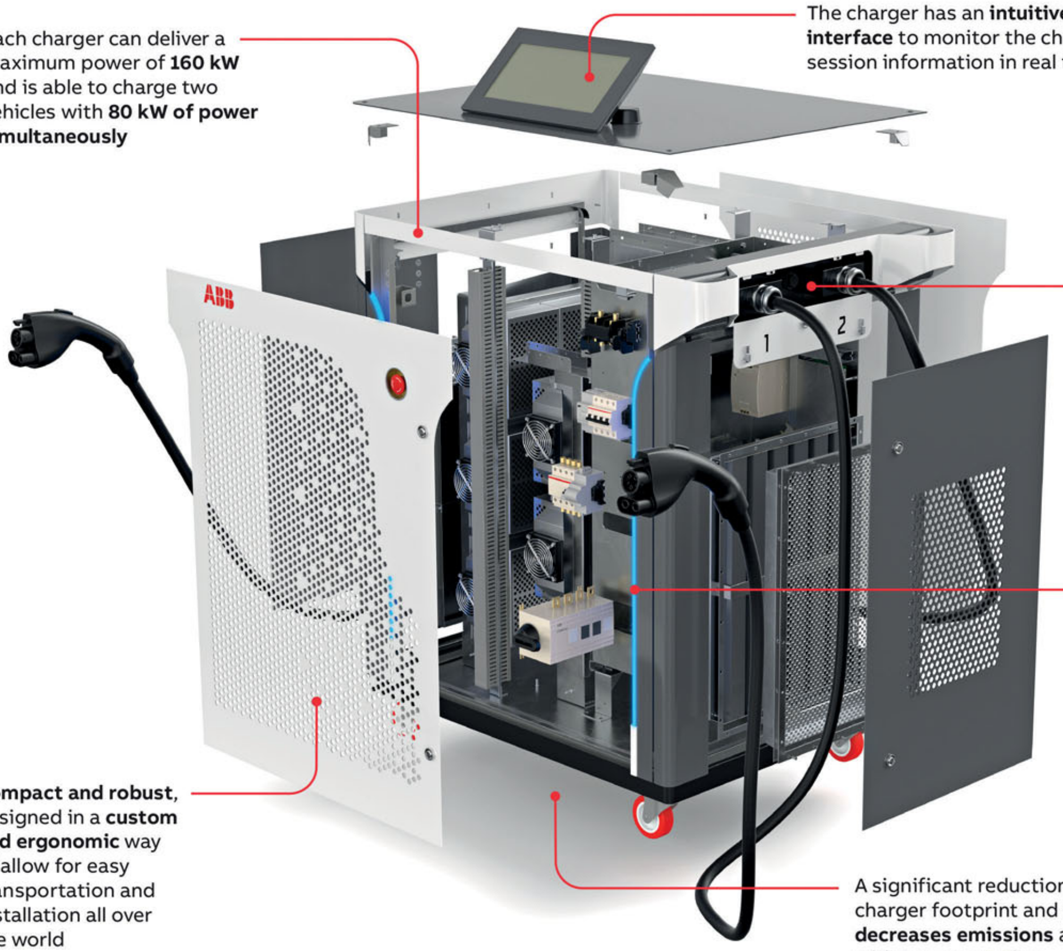

Each charger can deliver a maximum power of **160 kW** and is able to charge two vehicles with **80 kW of power simultaneously**

The charger has an **intuitive user interface** to monitor the charge session information in real time

The **'double charging' capacity** from one unit means teams require just one charger for both cars

Built-in LED lights display the current **State of Charge** (SoC) of the cars

Compact and robust, designed in a **custom and ergonomic** way to allow for easy transportation and installation all over the world

A significant reduction in the charger footprint and weight **decreases emissions** associated with transportation

ABOVE Fast and efficient charging has inevitably been a hot topic. Season 9 is ABB's first as Official Charging Partner for the series. Its race charger is shown here

Ciliberti confirms: "It's something that we're going to showcase as we progress through the current season. We went for a bespoke cell as we knew these high power demands would be part of Gen3. Challenges are definitely expected for this kind of technology, but we have found a fix."

Perhaps not surprisingly, the biggest technical challenge during the development of Gen3 is said to have been ensuring reliability and consistency across all the batteries in the fleet. But it was by no means the only one. The biggest conceptual change on the car was the addition of a front powertrain, and its impact on the dynamics.

"The blending that you do between the hydraulic brakes and the regen at the front was also one of the of the key points that we had to learn during the car's development," notes Ciliberti.

New tyres

The new Hankook tyres are more of an evolutionary change, but one that the teams are still getting to grips with. Nearly 30 per cent of the new tyre comes from sustainable components, while the construction is understood to be quite different from the old Michelin tyre.

"The teams worked with the previous tyre for eight seasons, so it's a big change," says Ciliberti. "Hankook has done an incredible job, but they're learning their way through what is required for the championship. We have a tyre that's a really good starting point, with consistent behaviour through the different sessions. There is room for performance optimisation, but that's something we're looking at for the mid-life evolution of Gen3."

For the time being, Ciliberti says, the emphasis is on the teams to exploit the current package: "We're very happy with the product, and there's plenty for the teams to do when it comes to learning the car and how to get the best out of it. I think that's where the biggest challenge will come for Season Nine, and I'm sure we'll see a significant performance increase throughout the season."

> *"The transition from Gen2 to Gen3 is as significant as anything seen in modern F1"*

Beyond that, however, the FIA and the Formula E promoters are already looking at a significant package of upgrades – a Gen3 Evo package, you ▶

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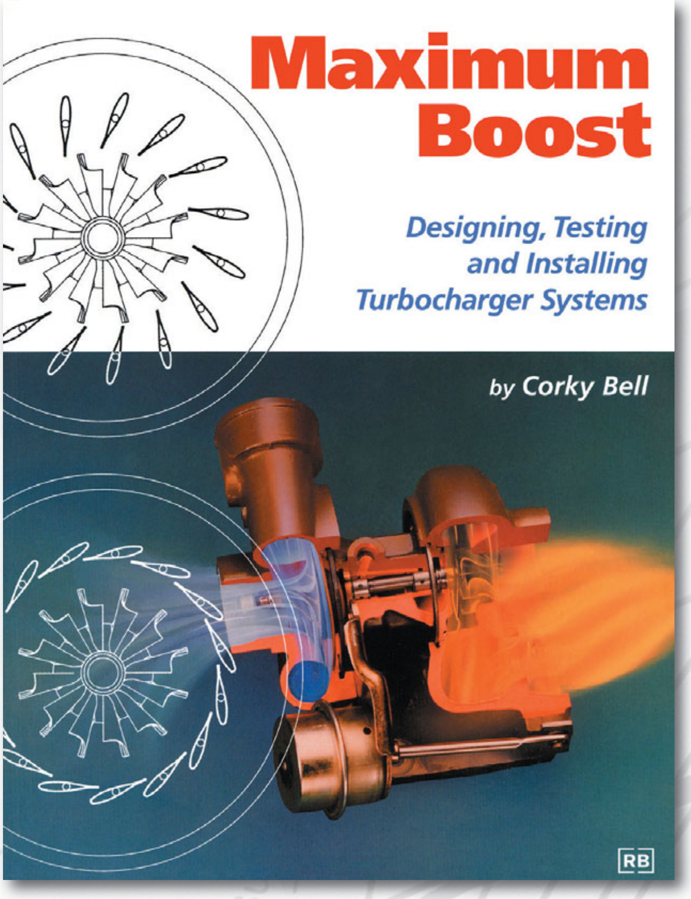

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might say – although it's not been confirmed when this might be introduced.

"One of the things we're looking at doing is giving the car a four-wheel drive capability in traction too [not just in regen]," comments Ciliberti. "We're looking at some specific scenarios where we could deploy four-wheel drive. Another area we're considering is aerodynamics, with some potential improvements there too."

Part of the thinking behind the Attack Charge concept is to reflect the important role that recharging plays in electric car ownership. There's also a strong focus on technology transfer, Ciliberti explains: "Road relevance plays a part in what we deliver as a common package, including the battery and the showcasing of fast charging. But it's also something we keep in mind with the rear powertrain, which is open to the manufacturers. The reason we keep parts like the chassis and the aero standard is that we want the efforts of our manufacturers to be focused on technology that is road-relevant."

More freedom

The Gen3 Evo rules are unlikely to have a significant impact on which aspects of the hardware the manufacturers are allowed to design themselves. However, a number of manufacturers are known to be pushing for some degree of freedom in the battery development for Gen4. Last year, for instance, Porsche's head of motorsport, Thomas Laudenbach, told Race Tech that he hoped to see "freedom in certain, clearly defined areas [of the battery]".

> *"We want the efforts of our manufacturers to be focused on technology that is road-relevant"*

One of the wackier suggestions for Gen4 is understood to be an autonomous driving mode for use in the pitlane or while following the safety car.

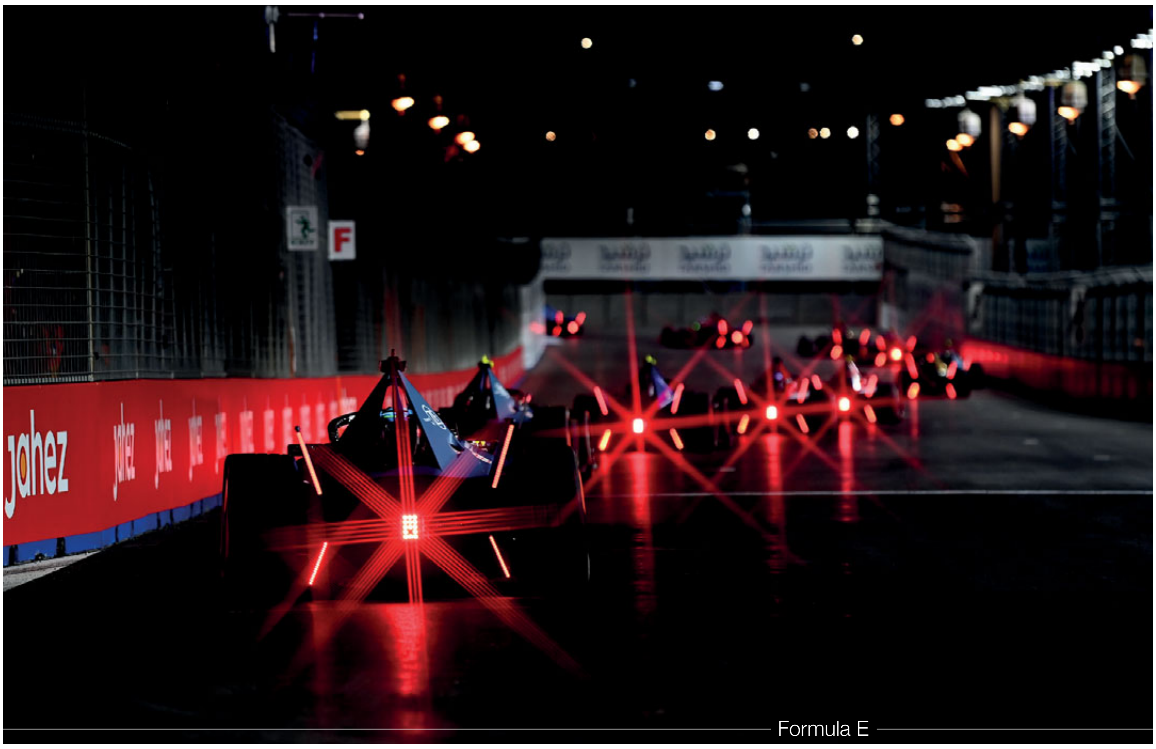
Ciliberti isn't ruling anything out. "Gen4 will open the door to everything," she says. "We haven't gone through the plans in detail yet, but it allows us to keep an open mind."

Sustainability is bound to remain a key trend too. The series was the first in the world to be certified with a net zero carbon footprint back in 2020 – thanks to a combination of emissions reductions and carbon offsetting. It's thought that the Gen3 platform represents the first major racing car ever to be designed to specific sustainability criteria from the outset.

"The construction of the car has

ATTACK MODE

ABOVE The evidence of the opening races is that Porsche has stolen a march on rivals in coming to terms with the Gen3 quickly



Formula E

LEFT Regenerative power has more than doubled from 250 kW to 600 kW on the new cars

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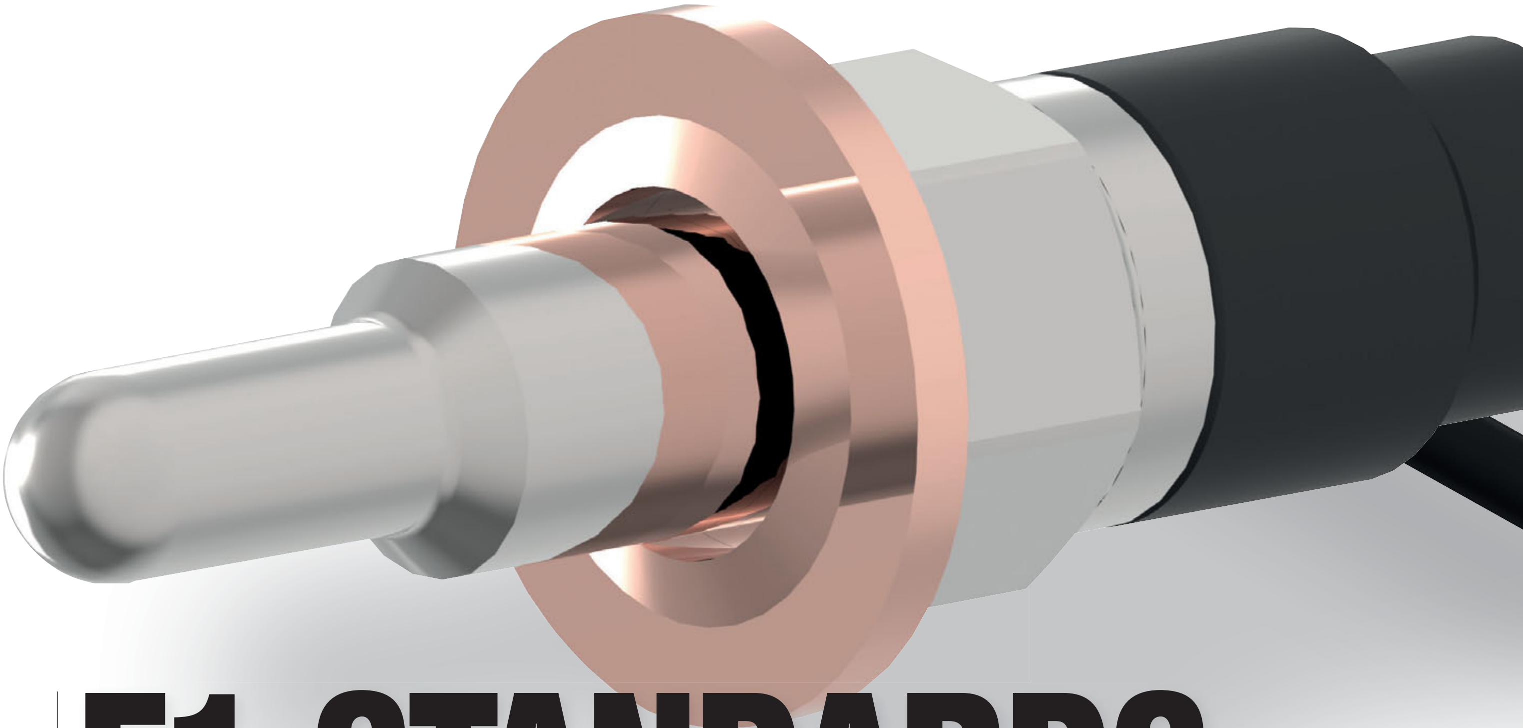
FRONT POWERTRAIN

ABOVE The biggest conceptual change has been the addition of a front powertrain from Lucid/Atieva. The move enables four-wheel energy recovery and, in the future, perhaps also deployment

lifecycle impact at its very core of its development," comment Ciliberti. "All the suppliers for the common parts are FIA three stars accredited, our highest level of Environmental Accreditation, and we've worked through the lifecycle impact to make a step change from Gen2 to Gen3. I think Gen4 will be an even more interesting exercise in terms of how we maximise the sustainable materials in the car and reduce its footprint even further."

For now, though, all eyes are on Season Nine and the new Gen3 cars. The first round in Mexico gave us a promising blend of close racing and apparent reliability, with three powertrain manufacturers and four different teams in the top five (including newcomers McLaren). How things pan out across the rest of the season will depend heavily on how quickly the individual teams and drivers can unlock further potential in the new package.



F1 STANDARDS – BUT WITHOUT THE PRICE TAG

McLaren Applied's new Sport Range sensors are designed to bring F1-grade technology to more affordable markets. **Chris Pickering** reports

PERHAPS the ultimate endorsement for a motorsport product is to find favour in the uncompromising world of Formula 1. It's by no means the only high-tech series out there, but the freedom and the resources granted to engineers in F1 allow concepts to be honed to an unprecedented degree. If a product can thrive in that environment, it truly is world class.

But an F1 pedigree can be a double-edged sword. Mention the 'F' word and it conjures up expectations of a price tag to match.

That's exactly the sort of assumption that McLaren Applied's motorsport director, Richard Saxby, is keen to dispel with the company's new Sport Range sensors. Introduced at this year's Autosport International show, they are designed to bring F1-grade technology to more affordable markets.

"We've got this amazing brand, which is well known for its quality performance and reliability. Our standard ECU, for instance, has now covered over 1.7 million kilometres without a single in-race failure. But the biggest challenge in more affordable markets is not to scare people away with that reputation," he admits.

The core of each sensor is not just F1-inspired, but lifted straight from McLaren Applied's Pro Range. Performance and reliability are said to be exactly as you might find on the grand prix grid, just without the bewildering array of customisation options.

"Packaging is super important in Formula 1. In that market, individual teams have very specific demands for the size, weight and shape of the sensor," comments Saxby. "They may have their own wire specifications or cabling requirements; different temperature ranges or bespoke mounting points. Nothing at that level is standard."

The template for the Sport Range was laid down after the company began supplying components to Formula E teams. These products took a fixed specification from the almost limitless customisation options within the Pro Range, dramatically simplifying the manufacturing process. McLaren Applied

ABOVE Fluid (top left), speed (top right) and infrared (above) offerings are among the extensive new range of sensors

has since adopted a similar approach for the new Sport Range, but with larger production volumes helping to reduce costs further.

"We anticipate a lot of the interest coming from series promoters or manufacturers of single-make championships like the Lamborghini Super Trofeo, the Ferrari Challenge or the Porsche Carrera Cup. There, you can have 500 cars around the world using the same components," notes Saxby.

Off the shelf

Another key change will be the business model. With confidentiality and bespoke tailoring so high on the agenda, Formula 1 teams tend to prefer dealing direct with the manufacturer. For these off-the-shelf sensors, McLaren Applied expects most of the sales to come through its network of international distributors – namely HCI Systems for the UK, Aviorace (based in Italy) for Europe and North America, and Le Mans Co Ltd for Japan. This retail arrangement should also slash lead times, as well as making spares easier to sort and allowing rebuilds to be carried out locally.

> *"Performance and reliability exactly as you might find on the grand prix grid"*

The simplified range of offerings includes air and fluid temperature sensors, a series of speed and position sensors, a barometric pressure sensor, an infrared temperature sensor and a 3-axis accelerometer. All come in a hard anodised coating – blue to differentiate them from the existing black ▶

sensors – with standardised mounting systems.

"Our aim was to cover the complete sensor set that you would need on a typical high-performance racecar," comments Saxby. "You can measure pretty much everything you need to with that particular sensor range, whether it's aerodynamic pressures, speed, displacement or temperatures."

> *"Over 1.7 million kilometres without a single in-race failure"*

While the production volumes are proportionally higher than those in F1, the batch sizes are still relatively small, allowing the same production techniques and machinery to be employed, Saxby explains.

"As we usually deal in ones and twos, there's no reason why we can't make 20s and 30s while we've got the line running," he notes. "The design and production of the internal elements is exactly the same. The casing is still sealed to the same water ingress requirements and things like that."

Branching out

Aside from single-make series, McLaren Applied is also hoping to branch out into other mid-level categories. Beyond that, it's thought that the sensors would also appeal to LMH, LMDh and MotoGP teams.

In time there are also likely to be more electric and hybrid series, which can bring their own additional challenges, but the sensors have been designed with these in mind.

"Fundamentally, an electric vehicle has the same requirements to monitor the performance and health of the car. That doesn't change," comments Saxby. "We've designed these sensors – both the Sport Range and the Pro Range – from the outset to be protected against things like external electromagnetic fields and over-voltage."

General reliability is also a key focus, ▶

Lamborghini

ABOVE Interest is anticipated from series promoters or manufacturers of single-make championships like the Lamborghini Super Trofeo

BELOW The same production expertise and techniques are employed for the Sport Range as for the F1 products

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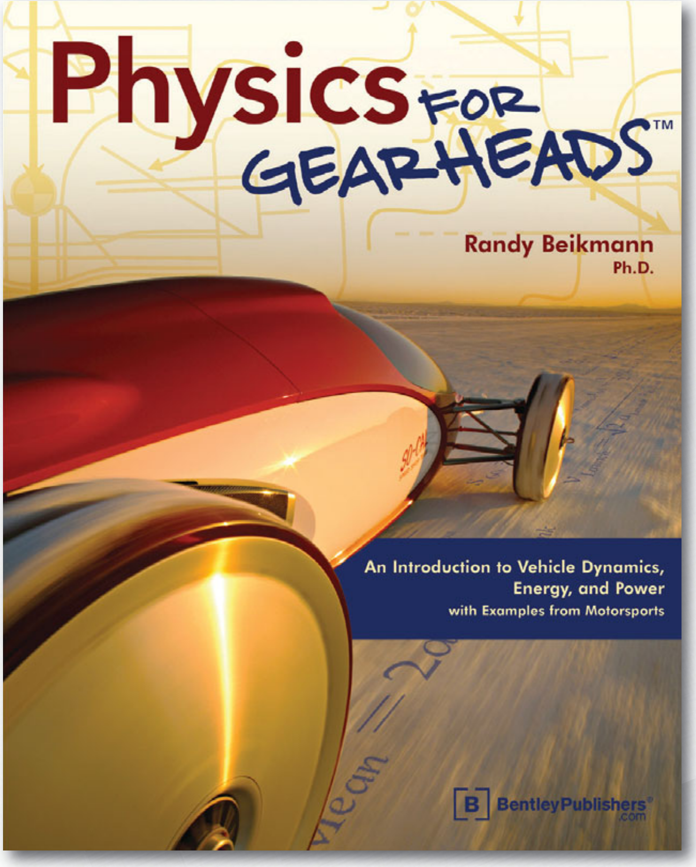
Physics FOR GEARHEADS™
Randy Beikmann
Ph.D.
An Introduction to Vehicle Dynamics, Energy, and Power
with Examples from Motorsports
B BentleyPublishers.com

THERE is no better way to learn physics than by having a problem to solve.

As a gearhead, you have a secret advantage when it comes to understanding physics: you see it at work every time you solve a problem with your car or watch a motorsports event. The experience you already have tuning cars or motorcycles is your virtual physics lab. Physics for Gearheads will show you that if you can learn about cars, you can learn about physics.

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Note on the units of measurement used in Physics for Gearheads: This book outfits the reader to work in SI or British Engineering units.

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and something Saxby says that the internal elements have already proved out over years of Formula 1 use. "We think the USP of these sensors will be F1-style reliability, and hence a longer lifetime and a more dependable unit for a comparable price to what's out there currently," he claims.

The new sensors aren't the first Sport Range products to make it to market. McLaren Applied has already launched a Sport Range version of its ECU, without some of the more complex functionality required for Formula 1. Customers are said to include works WEC teams.

"In terms of ECUs, the manufacturing costs for the Sport Range units are similar to the Pro Range. But they're slightly simpler in terms of their capabilities, which means that our support costs are reduced, and that can be passed onto the customer," comments Saxby.

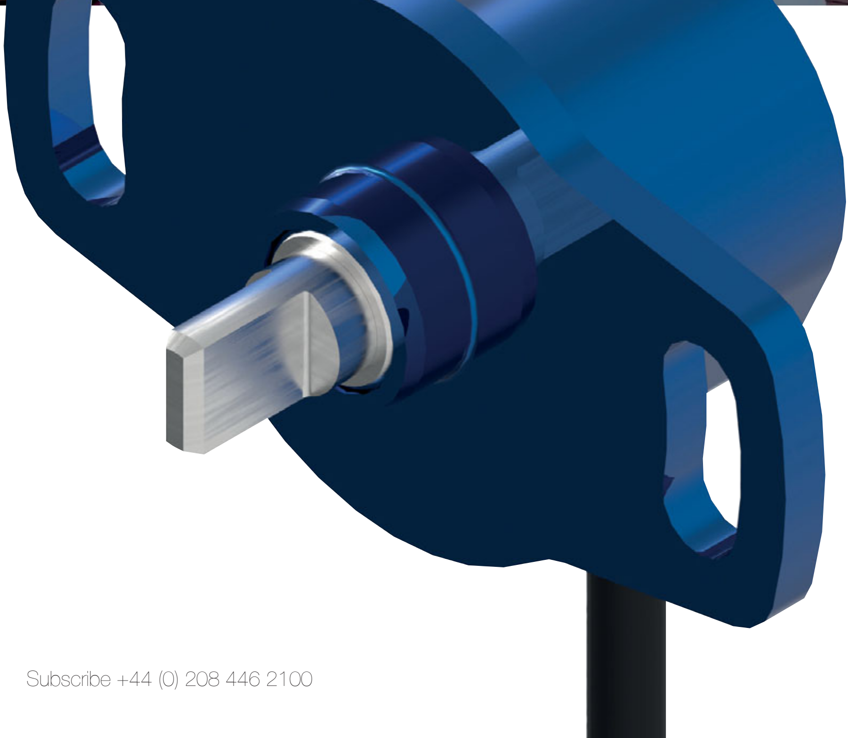
> *"Fundamentally, an electric vehicle has the same requirements to monitor the performance and health of the car"*

Coming soon...

Other products are due to arrive later this year. First on the list is a Sport Range alternator – a fixed specification unit aimed principally at GT teams. Alongside it comes the new Tyre Pressure Monitoring System Lite, which will again be based on a simplified version of the Formula 1 system, with a basic tyre pressure and temperature readout coming from a serviceable unit

ABOVE From F1 to grassroots, data is king in motorsport

RIGHT Each sensor is supplied in a hard anodised coating and with standardised mounting systems



featuring a removable battery.

Beyond that, Saxby says the company will be looking into other ideas: "Aerodynamic efficiency is becoming more and more important. If we had interest from the mid-range market for, say, a sensor to measure aerodynamic flow, that's something we could bring into the field."

There's no secret sauce to McLaren Applied's approach. Away from the money-no-object world of Formula 1, there simply isn't the need for dozens of different variants produced in single-digit quantities. Freed from such constraints, the company says it can deliver products with F1-grade performance. Just without the scary price tag.

Chris Owens/IndyCar

ABOVE Michael Andretti has been dismayed by the attitude of "greedy" F1 teams

WHEN SPEED *MEETS GREED*

Sergio Rinland questions the opposition to Andretti's Cadillac entry becoming F1's eleventh team

THERE was a time when participating in Formula 1 was every lower formula team's ambition; that is how many current F1 operations started life, most of them in the '60s, others in the '70s or '80s. Many teams in those decades fell by the wayside due to financial constraints; that was the nature of the business in those days.

Many came and went, but the top teams at the time, be it Ferrari, McLaren, Williams or Benetton, never gave a second thought to the newcomers.

By the late '80s, there were so many new teams the FIA resorted to pre-qualifying to select the top 24 cars, the maximum allowed to compete in any race. I, for one, 'enjoyed' those 7am runs on Fridays when Brabham was obliged to pre-qualify because, not being present in 1988, it was deemed to be a new team in 1989.

Fast-forward to 2008 and the withdrawal of mighty Honda had F1's power brokers concerned. It left only 20 cars (as now, what a coincidence!) on the grid and the sword of Damocles hanging over its head: if more manufacturers chose to leave (as did Toyota and BMW years later), there would be only 16 cars on the grid.

This inspired the quest for new teams, no matter how small. It brought three new entrants, HRT, Marussia (later Manor), and Lotus. We all know how that finished: they were promised a budget cap which never came, so they quickly ran out of the little money they had.

The selection process was such a failure that it prompted the 'old' teams to raise the entry fee for new teams to a level only afforded years later by Haas. As Ferrari's junior team, no one opposed their entry.

After the last Concorde Agreement, the money distribution started to be more reasonable, with the oldest and better teams always receiving the biggest portion of the cake.

Come 2021 with the controversial budget cap, and now the top teams actually made a profit. Even the last team received about half of what they are allowed to spend, having to find 'only' 50 to 60 million dollars – a lot less than the hundreds of millions of sponsorship they had to source in the past.

You know where this story is leading me. Everybody welcomed Audi with open arms when they bought Sauber. They will also welcome Porsche if and when they partner with an existing team after their failed deal with Red Bull. The latter's tie-up with Ford would also, presumably, prompt euphoria.

So far, so good. As long as only 10 teams are participating, everybody is happy.

But someone always throws a spanner in the works. That someone is none other than Michael Andretti (son of 1978 F1 World Champion Mario, a superstar not only in the US) with his eponymous team.

F1 is owned by an American group (Liberty Media), there will soon be three F1 races in the US, so it became attractive to Andretti to enter F1 after being very successful in everything they have entered so far. But this time, F1 teams are not happy at all, arguing that even with GM behind it (through the luxury brand Cadillac), Andretti cannot be serious because they will use a rebadged Renault engine.

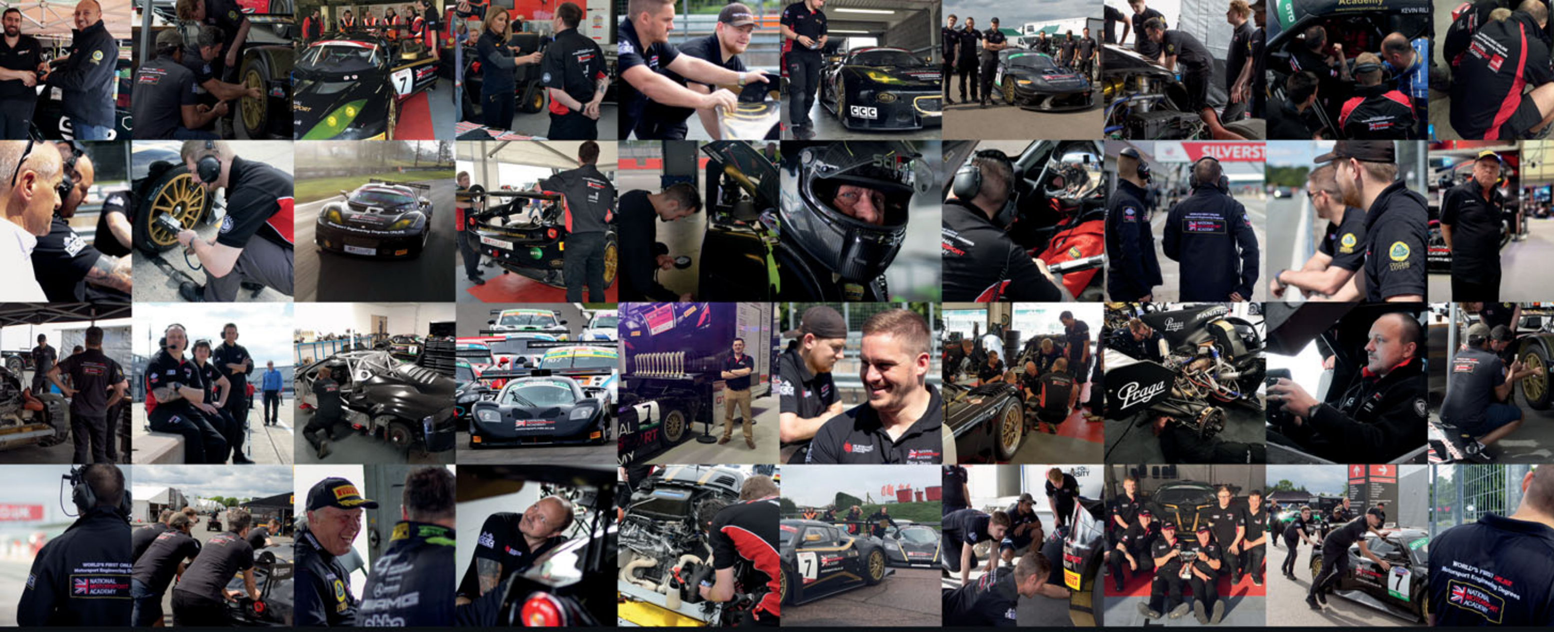
Slice of the cake

All because he wants to come with a new team. After three years that 11th team would be entitled to a slice of the cake, diluting everybody else's share. This would reduce the top teams' profit and the smaller teams would have to find some more sponsorship money.

> *"The talk is of Andretti 'underestimating' F1; perhaps the F1 teams are underestimating Andretti?"*

If this sounds selfish, it's because it is. But F1 is now more a business – some would say more of a vipers' nest – than it has ever been, and no one wants to lose. But where the established teams whisper that Andretti is 'underestimating' F1, perhaps F1 is in danger of underestimating Andretti? The current teams should remember that Andretti is not HRT or USF1, it is an iconic name and more successful than Haas has ever been.

For US motorsport, F1 fans, Liberty Media and the FIA, this should be a no-brainer. The Andretti brand might not be as big as Ferrari, but it will attract new sponsors and new fans to F1, which will translate into a bigger cake to divide.



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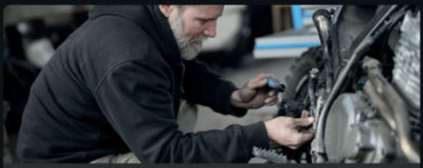

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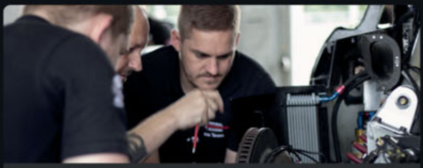

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